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THE OHIO RIVER FLOOD OF MARCH, 1933[1]

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In March, 1933, the Ohio River Valley experienced the most severe flood since the disastrous overflow of 1913. From Point Pleasant, West Virginia, to Shawneetown, Illinois, the crest stage of this most recent flood was the highest since that of 1913, while at Cincinnati the river reached the fifth highest stage in its recorded history. Upstream from Point Pleasant the flood of March, 1933, was less severe than that of 1927. Attendant upon the overflow was the usual destruction of life and property as well as disruption of both land and water traffic along the Ohio Valley.

The cause and character of this flood becomes of special interest at this time because of the inauguration of the Muskingum Valley Project and proposals for the construction of an extensive system of flood-control reservoirs designed for the permanent prevention of floods in the Ohio River and its tributaries. Such a system would cost approximately $211,000,000 according to the estimate of Colonel Roger M. Powell, army engineer in charge of the Cincinnati office.[2] Under the proposed plan flood crests would be reduced some eight feet and river navigation would be facilitated by the maintenance of a standard water depth. The propensity of the Ohio River to flood is indicative of the need for control works. The complexity of the natural phenomena which lead to flood conditions in the Ohio Valley suggests the need for a comprehensive study of the causal factors.

[1]The writer wishes to acknowledge the assistance of Dr. Guy-Harold Smith, Department of Geography, Ohio State University, particularly in the preparation of the maps.

[2]The Enquirer, Cincinnati, May 3, 1934.

RECURRENCE OF FLOODS

Floods in the Ohio River Valley are not an unusual phenomena. River records for Cincinnati, located about midway between the mouth of the river and Pittsburgh, show that in the seventy-two-year period ending in 1931, flood stage has been reached at this point no less than thirty-five times. On this basis a flood may be expected about every other year. However, the river departs from the average in regard to the timing of its floods. On but eleven occasions has the flood occurred on alternate years. On five occasions floods have been separated by two-year intervals, once by a three-year interval and on two occasions five year periods passed without the river leaving its banks. Twice floods have occurred on three successive years and a four year period, ending in 1918, was featured by a flood each year.

The seasonal occurrence of high water shows less irregularity in the seventy-two year period under consideration. February leads with twelve floods, March is second with nine, January and April have six and five respectively, while December and August are each credited with one.

The Ohio River shows a great variability in the severity of its floods, not only as measured by comparisons of crest levels at a particular station, but also as measured by comparison of crest levels taken at several points along the stream. Cincinnati, taken as an example of a particular station, has recorded a total of thirty-five floods of which only two have approached a crest level of twenty feet above flood stage, and only six have reached a level of ten feet above the river's banks. In contrast, eighteen of the thirty-five floods recorded at this station have had a crest of less than four feet above flood stage. In regard to comparison of flood severity at selected points along the river, the March, 1933 flood produced the highest crest since 1913 for stations from Point Pleasant, West Virginia, to Shawneetown, Illinois. However, five floods at Pittsburgh since 1913 have exceeded the crest level of the 1933 flood at that point, while the flood of 1922 produced a higher crest at Paducah, Kentucky.

The character of the floods in the Ohio Valley as revealed by the existing records permit few valid generalizations, except perhaps, that floods do occur frequently. It is important, however, that the cause and character of these floods be deter-

mined and this information be used as a background for effective flood prevention and control works.

THE CAUSE AND CHARACTER OF THE MARCH, 1933, FLOOD

In the report of the United States Geological Survey on the Ohio Flood of 1913, the authors remarked that it was fortunate that the precipitation which caused the flood had occurred first on the lower tributaries of the river, giving them a chance to run out before the floods of the upper tributaries had entered the main stream. They suggested that the reverse might occur at some time with one flood reinforcing the other with disastrous results.[3] This forecast came true in the 1933 flood with the important exception that this most recent flood did relatively little damage.

Floods in the past have been due to a variety of causes, namely, excessive rainfall, rapid melting of accumulated snow, failure of reservoirs, forming and breaking of ice jams and breaking of levees.[4] The flood of 1913 resulted from excessive rainfall on saturated ground. The flood of 1933 resulted from exceedingly heavy precipitation, but its severity was intensified by the peculiar distribution of the rainfall in the middle and upper drainage basin of the Ohio River. There were two distinct rainstorms in the basin to which the flood may be attributed. The first storm occurred on March thirteenth, fourteenth and fifteenth, and the second on March eighteenth, nineteenth and twentieth, with a rainless period of about forty-eight hours intervening. During each storm rain was general over the entire drainage basin, but the maximum fall in the first storm occurred in the upper valley while that of the second storm was centered in the middle portion of the basin.

THE FIRST STORM

On March twelfth, the day prior to the first storm, the Ohio Valley experienced fair weather and rising temperatures. The river was at about average stage from Pittsburgh to Cairo, and the ground was not overly moist since precipitation for the preceding months of January and February was below normal for the greater part of the drainage basin. An extensive

[3]A. H. Horton and H. J. Jackson, "The Ohio River Flood of March-April, 1913." U. S. G. S., Water Supply Paper No. 334, 1913, p. 46.
[4]Ibid., p. 13.

low pressure area was moving eastward over the Northern Rocky Mountains. On Monday morning, March thirteenth, the first day of the first storm, this Low was centered over Iowa. Violent thunder storms occurred throughout the Ohio Valley and rain was general east of Louisville. The turbulent

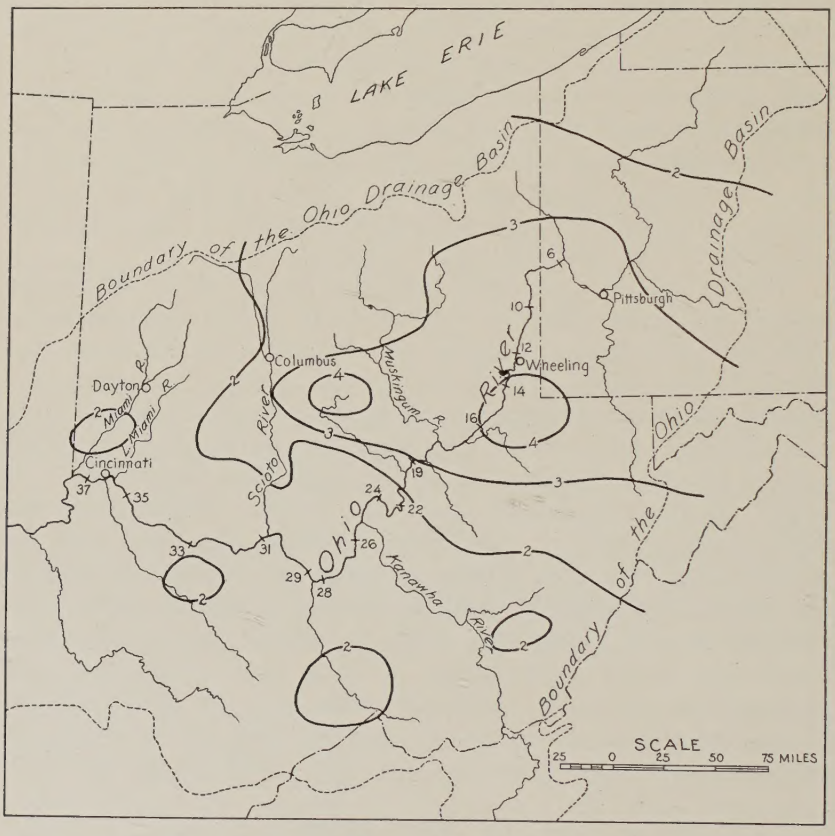

FIG. 1. Distribution of precipitation for March 13, 14, and 15, 1933. Note the heavy rainfall in the upper Ohio Valley with over four inches in the Wheeling district and on the headwaters of the Hocking River. (Numerals along the Ohio River indicate the location of dams.)

character of the atmosphere is indicated by the observations at Lunken Airport, Cincinnati. Calm wind was recorded at the surface while an eighty-three miles an hour gale was blowing at an elevation of 2,500 feet above the surface.[5]

[5]Daily Weather Map. Cincinnati Office of the Weather Bureau. March 13, 1933.

By the fourteenth, the second day of the storm, the Low had advanced to central Michigan and had developed a secondary which was centered over Arkansas. This trough of low pressure, crossing the Ohio Valley, brought the second day of general rain to the district. On the morning of the fifteenth the Low and its secondary had merged and were centered over eastern Pennsylvania. During the day the rain ceased and the skies cleared in the Ohio Valley.

The rainfall which accompanied the first storm reached its maximum amount in the Wheeling district and on the headwaters of the Hocking River, each district receiving about four inches of rain as a total for the three days. The average rainfall for the entire month of March is three and one-tenth inches at Wheeling and two and nine-tenths inches at Athens on the Hocking River. The distribution of rainfall in the Ohio Drainage Basin for the three-day storm period is indicated on Figure 1. The three-inch isohyet includes the greater part of the basin east of the Muskingum River, while the two-inch isohyet reaches as far west as Wilmington, Ohio. In addition, isolated areas receiving two or more inches of rainfall are found in the middle Ohio Valley.

The most notable feature in the distribution of the rainfall of the first storm is its maximum in the upper or eastern portion of the Ohio Drainage Basin.

THE SECOND STORM

The two-day interval between the rain storms was featured by the passage of two anti-cyclones in succession over the Ohio Valley. Moving in from the West Coast, however, was an extensive low pressure area that brought this period of fair weather to an end.

On the morning of the eighteenth this Low was centered over southern Kansas and covered the greater part of the United States with the exception of the Pacific Coast. An equally extensive high pressure area spread over Canada with its center north of Lake Huron. Under such conditions the predicted track of the cyclone led south of the Ohio Valley, probably through Tennessee. On the expectation that the northern section of the Low would pass over the valley, the Cincinnati Office of the Weather Bureau predicted unsettled weather for the eighteenth and clearing weather for the

nineteenth.[6] The Low, however, turned at right angles to its estimated course and moved north at a slow rate. The movement of the storm center from the eighteenth to the twentieth is estimated to be at a speed of about thirteen miles per hour or less than one-half the normal winter rate. From

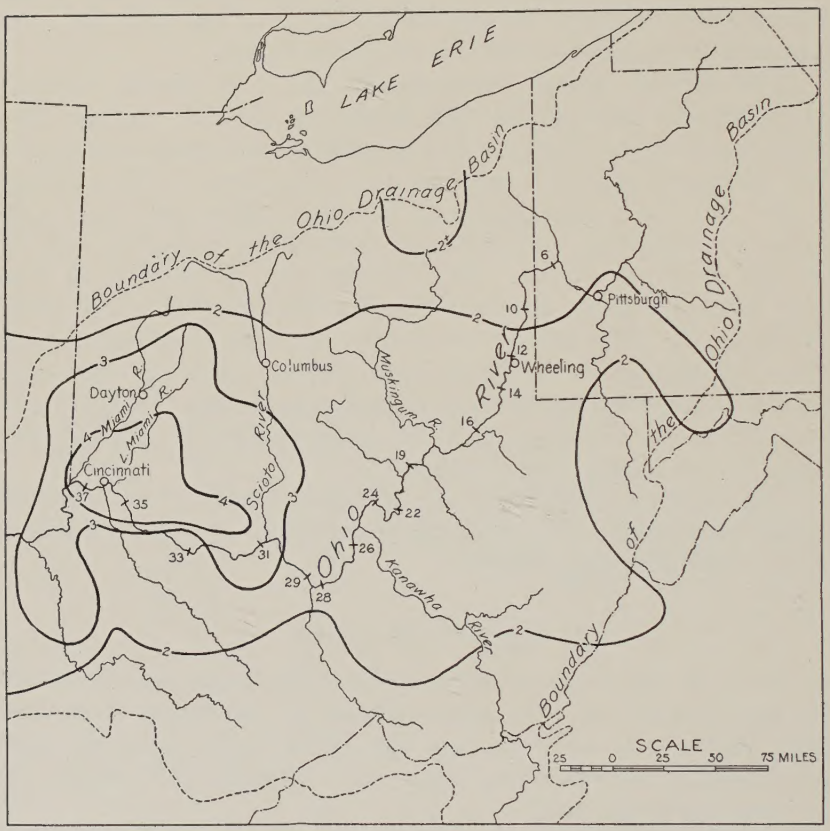

FIG. 2. Distribution of precipitation for March 18, 19, and 20, 1933. The rainfall of the second storm reached its maximum in the Cincinnati district. Compare with Fig. 1.

its position over Kansas on the eighteenth the Low moved over Cincinnati on the twentieth and on the twenty-first was centered over lower Michigan. From here it moved northeastward down the St. Lawrence Valley.

[6]Daily Weather Map. Cincinnati Office of the Weather Bureau, March 18, 1933.

The rainfall which accompanied the passage of this cyclone over the Ohio Valley began falling on the afternoon of the eighteenth and was general and more or less continuous over the entire valley until the morning of the twentieth. In contrast to the first storm, the maximum fall occurred in the middle rather than the upper valley, and the total amount for the three-day storm period was greater. (See Fig. 2.)

Five and two-tenths inches of rain fell at Cincinnati, the heaviest recorded in either storm. "The greatest rainfall [at Cincinnati] in thirty-six hours was nearly five inches, and the rainfall was at the rate of one inch per hour for a considerable time."[7] Two inches or more of rain occurred in nearly all of the Ohio Basin in the second three-day storm period.

The approach of a third storm in the series which brought flood conditions to the Ohio Valley in March, 1933, gave rise to the possibility of an even more severe flood than was experienced. This low pressure area was centered over northern Texas on the twenty-second of March and the presence of a high pressure area over Florida enhanced the probability of the movement of the storm area over the Ohio Valley. The prospect of a third rainstorm over the then flood-stricken district was regarded with apprehension. Special data on the progress of this low were collected by the Cincinnati Office of the Weather Bureau and two special Weather Maps were constructed in one day.[8] Fortunately, the storm moved eastward over Tennessee and the precipitation in the Ohio River Basin was negligible.

The total precipitation which fell in the upper and middle drainage basin of the Ohio River from March thirteenth to March twentieth amounted everywhere to more than three inches. Thus, in the area at large, the rainfall of an eight-day period about equaled the normal precipitation for the entire month of March. The maximum fall for the entire basin was in the Cincinnati district where seven and eighty-five hundredths inches were recorded. In the upper valley, Wheeling had a total of six and fifty-four hundredths inches, while near the mouth of the Muskingum River six and forty-two hundredths inches of rain fell in the two storm periods.

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[7]R. T. Zoch, "Monthly Weather Review." U. S. W. B., June, 1933, p. 16.
[8]The Enquirer, Cincinnati, March 23, 1933.

The fact that in this particular flood period the heaviest rainfall occurred within a few miles of the Ohio River itself acquires an added significance in regard to the proposals to control the flood waters of the Ohio by means of storage dams

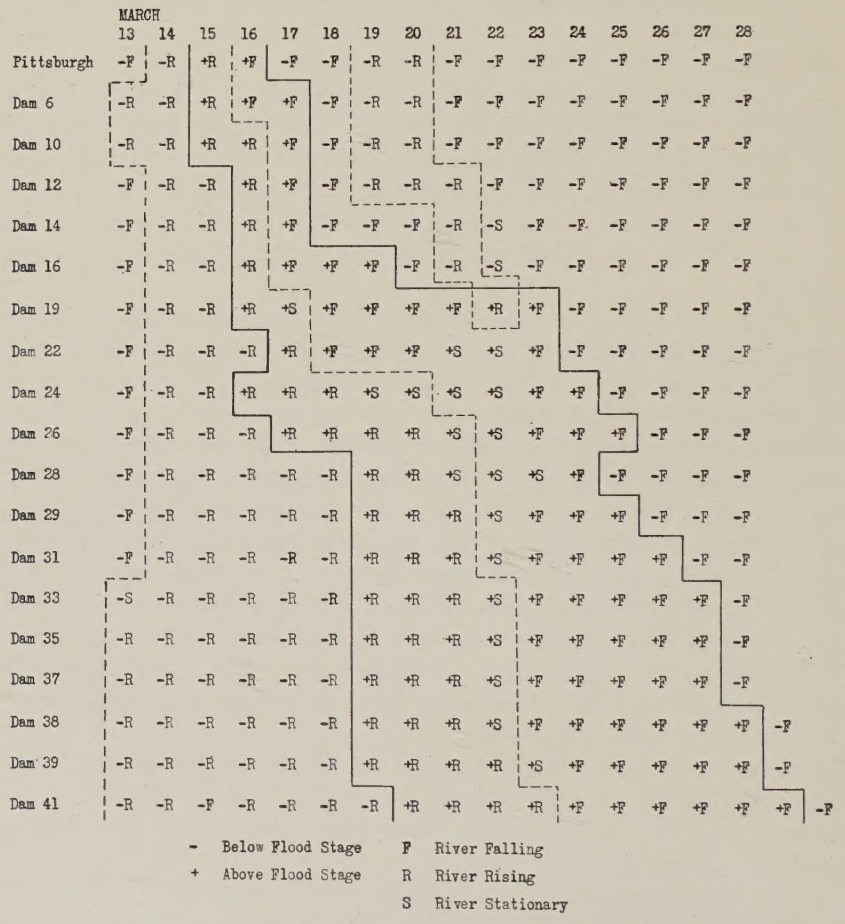
MARCH
13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Pittsburgh -F -R +R +F -F -F -R -R -F -F -F -F -F -F -F -F
Dam 6 -R -R +R +F +F -F -R -R -F -F -F -F -F -F -F -F
Dam 10 -R -R +R +R +F -F -R -R -F -F -F -F -F -F -F -F
Dam 12 -F -R -R +R +F -F -R -R -R -F -F -F -F -F -F -F
Dam 14 -F -R -R +R +F -F -F -F -R -S -F -F -F -F -F -F
Dam 16 -F -R -R +R +F +F +F -F -R -S -F -F -F -F -F -F
Dam 19 -F -R -R +R +S +F +F +F +F +R +F -F -F -F -F -F
Dam 22 -F -R -R -R +R +F +F +F +S +S +F -F -F -F -F -F
Dam 24 -F -R -R +R +R +R +S +S +S +S +F +F -F -F -F -F
Dam 26 -F -R -R -R +R +R +R +R +S +S +F +F +F -F -F -F
Dam 28 -F -R -R -R -R -R +R +R +S +S +S +F -F -F -F -F
Dam 29 -F -R -R -R -R -R +R +R +R +S +F +F +F -F -F -F
Dam 31 -F -R -R -R -R -R +R +R +R +S +F +F +F +F -F -F
Dam 33 -S -R -R -R -R -R +R +R +R +S +F +F +F +F +F -F
Dam 35 -R -R -R -R -R -R +R +R +R +S +F +F +F +F +F -F
Dam 37 -R -R -R -R -R -R +R +R +R +S +F +F +F +F +F -F
Dam 38 -R -R -R -R -R -R +R +R +R +S +F +F +F +F +F +F -F
Dam 39 -R -R -R -R -R -R +R +R +R +R +S +F +F +F +F +F -F
Dam 41 -R -R -F -R -R -R -R +R +R +R +R +F +F +F +F +F +F -F
- Below Flood Stage
+ Above Flood Stage
F River Falling
R River Rising
S River Stationary

FIG. 3. Progress and duration of the flood. The broken lines inclose the periods of rising water, while the solid lines indicate the flood interval at selected stations along the Ohio River. Note the difference in the incidence and duration of the flood in the upper and middle valley.

on the headwaters of the major tributaries. The precipitation above the storage dams of the Miami Conservancy District averaged about three inches, while below the control works the rainfall for the flood period averaged about five inches. As a result of the peculiar distribution of rainfall in the Miami

Valley, minor overflows occurred in the vicinity of Middletown and Hamilton and the Conservancy Dams were of little, if any, benefit in retarding the progress of the flood waters of the Ohio River. On the contrary, it is possible that the channel improvement on the Miami River south of Dayton speeded the runout of its waters, thus intensifying the flood of the Ohio River.

PROGRESS AND DURATION OF THE FLOOD

On the morning of March thirteenth the Ohio River was at about average stage from Pittsburgh to Cairo. The general rains which accompanied the first storm began on the morning of the thirteenth and continued until the afternoon of the fifteenth, with the heaviest precipitation occurring in the upper portion of the valley. In response to this storm the river rose throughout its upper and middle course and on the morning of the sixteenth was above flood stage from Pittsburgh to Dam Twenty-four (Pomeroy, Ohio). At Louisville, Kentucky, however, the river was at approximately the same stage as on the preceding day. (See Fig. 3.)

During the interval of rainless weather which prevailed from the afternoon of March fifteenth to the afternoon of the eighteenth, the crest of the flood waters passed downstream bringing flood conditions to the valley from Dam Fourteen (St. Marys, West Virginia) to Dam Twenty-nine (Ashland, Kentucky). Above Dam Fourteen the river had subsided to within its banks while below Dam Twenty-nine, although the river was approaching flood stage, the prospect was for a flood of minor character. It was estimated by the Cincinnati Office of the Weather Bureau on the morning of the eighteenth that the approaching crest would bring the river to a level of about fifty-two feet or approximately flood stage at that point.[9] On the afternoon of the eighteenth the rains of the second storm began, and while general over the entire valley, reached their maximum in the Cincinnati District. The rapid inflow of water from this second storm reinforced the waters of the first and changed what promised to be a flood of minor character into one of major proportions.

Since the rainfall of the second storm was relatively light in the upper portion of the valley, it failed to bring the river

[9]Daily Weather Map. Cincinnati Office of the Weather Bureau, March 18, 1933.

to flood stage again upstream from Dam Fourteen. At Pittsburgh the river had fallen to a level of about seven feet below flood stage on the morning of the nineteenth. Twenty-four hours later the run-off of the upper tributaries had filled the channel to within two feet of flood stage, but the maximum flow of the stream passed without a second period of overflow.

Down stream from Dam Fourteen, where the effect of the first storm was still expressed either by flood conditions or rising water, the run-off of the second storm increased the height of the then existing flood and extended the flood zone to the vicinity of Louisville, Kentucky.

The influence of the dual storms is seen in the difference in the duration of the flood period in the upper and middle Ohio Valley. At Pittsburgh the river was in flood for two days, while at Dam Sixteen the overflow persisted for four days. Below this point where the waters of the first storm were reinforced by those of the second the flood interval was noticeably longer. Dam Nineteen experienced an eight-day flood or twice that of Dam Sixteen. Here the crest of the flood was reached on the sixteenth, early in the flood period, but subsidence of the river was so retarded by the second storm that flood conditions prevailed for six days after the crest had passed.

In the middle portion of the Ohio Valley where the flood waters of the two storms were merged, the flood period was from eight to ten days with the crest occurring about midway in the interval. At Cincinnati, the river passed flood stage between nine and ten o'clock on the evening of the eighteenth, soon after the second storm began, and rose at an average of about one-tenth foot per hour until the crest was reached at 5 P. M. on the twenty-first. This crest stage was held without noticeable change for fifteen hours. The run-out of the flood waters at this point required about five and one-half days after the river had started to subside. The tendency for the flood period to become progressively longer down stream is indicated further by the fact that the river remained above flood stage for ten days in the Louisville district as compared with a flood interval of fourteen days at Paducah, Kentucky. For a period of thirty days, beginning March fifteenth, the Ohio River at some point in its course from Pittsburgh to Cairo, was above flood stage.

Any plan designed for complete control of the waters of the Ohio must have multiple objectives. The control works must be comprehensive enough to retard effectively excessive stream flow when floods threaten. This will permit the development of riverine properly with a minimum of danger of loss from floods, and render navigation dependable in all seasons. Furthermore, the system of control works must be so planned that in periods of deficiency a river stage of depth sufficient for navigation may be maintained by increasing the discharge from the storage reservoirs. Such a plan implies an efficient and centralized control. It also implies, according to preliminary estimates, an expenditure of over $200,000,000. If the monetary cost of this vast project be balanced against the benefits which would accrue to the nation from a controlled Ohio River and the undertaking be found economically desirable, there still remains the development of an effective system of control works. The distribution and timing of the precipitation in the Ohio Drainage Basin which resulted in the flood of March, 1933, exemplifys but one of the many problems inherent in the control of the major stream through regulation of the flow of its larger tributaries.

Morphology of the Algae

Fritsch has added another distinguished volume to the subject of algology in giving us for the first time a comprehensive account of the morphology of the algae in the English language. The aim of the book is to present "a broad treatment of the subject-matter, such as will give a general review of the characteristics and interrelationships of the diverse group of Protista . . ." Phases of ecology, physiology, and taxonomy are dealt with only in so far as they are of general morphological interest. Some attempt is made to discuss the results of the vast number of cytological investigations. An introductory division of 59 pages discusses algae and flagellates, special structural features, and the general course of reproduction in algae. The classes of algae are then treated in more detail in order: Chlorophyceae, Xanthophyceae (Heterophyceae), Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, Euglenineae, and the Colorless Flagellata. Volume II will presumably treat the Myxophyceae, the Rhodophyceae, and the Phaeophyceae.

The book is of the greatest value to morphologists and students of the algae in its organization of data amassed during the last three or four decades and in the very complete and carefully selected references to literature.

American algologists will be inclined to approve Fritsch's return to "Chlorophyceae" (instead of "Isokontae") and to his inclusion of Dinophyceae and Euglenineae in a discussion of algal relationships. One could wish for more of the clarity and artistry attained by the late Professor G. S. West in the numerous figures and plates in the present volume.—L. H. Tiffany.

The Structure and Reproduction of the Algae, Vol. I, by F. E. Fritsch. xiii+791 pp. Cambridge, at the University Press; New York, the Macmillan Co., 1935. $8.00.

SOME INTESTINAL PARASITES OF *NATRIX SIPEDON* LINN., WITH NOTES ON THE IDENTITY OF *OPHIOTAENIA (TAENIA) LACTEA* LEIDY WITH *OPHIOTAENIA PERSPICUA* LARUE[1]

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The study on which this report is based was begun during the summer of 1929 at the Franz Theodore Stone Laboratory of Ohio State University at Put-in-Bay, Ohio. Additional material was collected from the same region during the latter part of the following summer.

Fresh water snakes of the species *Natrix* (*Tropidonotus*) *sipedon* Linn. were taken from the various islands of the Bass Islands region of Lake Erie. All of the organs usually inhabited by parasites were examined, but infestations were found only in the intestine. These species of parasites have not been previously reported for this host, though none of them were found to be undescribed species, with the possible exception of a single nematode of the genus *Camallanus*, as noted below.

The parasites found are as follows:

NEMATODA.

Camallanus sp.

A single male specimen, 10 mm. in length. The writer is unable to determine the species from the single specimen, or to state whether or not it is an undescribed species. Ward and Whipple list one nematode, *Physaloptera constricta* Leidy from this host species, but the specimen of this study is easily distinguished as of the genus *Camallanus* by the conspicuous lateral valve-shaped lips.

ACANTHOCEPHALA.

Leptorhynchoides (*Echinorhynchus*) *thecatus* Linton.

Natural host: various fresh-water fish.
Seventy-six specimens found in seven host specimens.
Heaviest infestation in single host: twenty-nine.

Acanthocephalans of this species were found in seven out of thirty-five host specimens, an incidence of twenty per cent. As many as twenty-nine were found in a single host. Identification of the species

[1]Contribution from the Zoological Laboratories of Northwestern University, Evanston, Illinois.

was checked by Van Cleave, who stated (in personal correspondence) that the infection in the snakes is very probably accidental, being acquired by eating the infected fish which are the natural hosts.

In addition to the adult specimens, large numbers of acanthocephalan cysts were found imbedded in the wall of the intestine in two of the host specimens. From the appearance of the proboscis and the size and number of the hooks in these cysts, they have been identified as being of the same species as the adults (*Leptorhynchoides thecatus*).

CESTODA.

Ophiotaenia perspicua LaRue.

Type Host: *Natrix rhombifer.*

Twenty-nine found in eleven of the thirty-five host specimens, an incidence of thirty-one per cent.

Heaviest infestation in single host: eight.

The only previous record of a cestode from *Natrix sipedon* is a description by Leidy (1855) of *Taenia lactea.* This description is so brief and so general as to be applicable to any species in the genus, and indeed to many others of the family Proteocephalidae. LaRue (1911) placed this as a *species inquirenda* in his genus *Ophiotaenia.* He later (1914: 208) suggested the probability of the identity of *O. lactea* with *O. perspicua.*

In view of the inadequacy of Leidy's description, it is impossible to state definitely whether the specimens found in this study are the same as his species. Since all of the cestodes found in this study were of the same species, however, it seems very probable that the one specimen found by Leidy in the same host species is the same. Furthermore, should another species of *Ophiotaenia* at any time be found in *Natrix sipedon,* it would be equally impossible to identify it with *O. lactea.* Hence, unless Leidy's type specimen can be produced for further study (LaRue states that it is not available—1914: 208), it is convenient and logical to assume the identity of the two species. It is therefore suggested that the name *Ophiotaenia perspicua* LaRue 1911 be retained for the species and that *Ophiotaenia lactea* (*Taenia lactea*) Leidy 1855 be considered a synonym, in recognition of complete, clear description, rather than of priority.

Although the dimensions of the tapeworms found in this study vary somewhat from those described for *O. perspicua,* there is no sufficiently outstanding difference to warrant the description of this form as a new species. The variations can be accounted for, in most instances, as due to differences in extension of the material at the time of fixation. In view of these differences, which may be noted in all platodes, a note of question of the infallibility of size alone as a diagnostic character of species is not out of order here.

The characters in which the measurements obtained by the present writer differ from those given by LaRue are listed and compared in Table I. The emended characters including the range of variations are also given.

TABLE I

Comparison of Characters of *Ophiotaenia perspicua* as Described by LaRue With Those Observed in This Study[2]

Character	LaRue	This Study	Emended Characters
Strobila	36 cm. × 2 mm.	3–60 cm. alive, largest 20 cm. when fixed.	3–36 cm. × 2.5 mm.
Neck	5–7 long × 0.17–0.425 broad	4–10 long × 0.185–0.5 broad	4–10 long × 0.17–0.5 broad
Mature proglottids	2 × 2	1.4–2.4 long 1.2–2.2 broad	1.4–2.4 long 1.2–2.2 broad
Ripe proglottids	3.8 × 1.2	2–6.8 long 0.7–1.6 broad	2–6.8 long 0.7–1.6 broad
Head	0.344–0.408 broad	0.190–0.247 broad	0.190–0.408 broad
Suckers	0.105–0.17	0.088–0.129	0.088–0.17
Cirrus pouch	0.255–0.32 long 0.08–0.09 broad	0.3–0.4 long 0.05–0.14 broad	0.255–0.4 long 0.05–0.14 broad
Ratio, length cirrus pouch to width proglottid	3–4 (?)[3]	3½–6	3–6
Uterus, pouches on each side	20–30	23–32	20–32
Embryo, size	0.018–0.021	0.0148–0.022	0.0148–0.022
Eggs, size outer membrane	0.045–0.1	0.066–0.125	0.045–0.125
Host	*Natrix rhombifer*	*Natrix sipedon*	

[2]All measurements in millimeters, unless otherwise stated.

[3]There appears to be a discrepancy in the figures given by LaRue at this point, for the maximum length of the cirrus pouch as given, divided into the breadth of the proglottid gives a larger figure.

The writer wishes to express his appreciation and thanks to Dr. F. H. Krecker, of Ohio University, for his interest and assistance in the survey portion of this research, and to Dr. H. J. van Cleave, of the University of Illinois, for the identification of the Acanthocephalan species.

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A VETERAN VOLUNTEER STATE SANITARY ASSOCIATION

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This is an account of the life-cycle of the Ohio State Sanitary Association which was born, flourished and died in the decade 1880–1890. The first and only secretary of the Association, R. Harvey Reed, M. D. (1851–1907), truly and fittingly called it at the time of its demise "a veteran volunteer sanitary association."

Few people in Ohio have any knowledge concerning this episode in the history of the state which brought together medical and lay representatives to labor for the creation of a state-wide program of health protection and promotion. This statement is especially true in the present day. We are so accustomed to the multiplicity of local, state and national health organizations which have appeared since the turn of the century that we are prone to assume that nothing existed before their establishment (1).

There is no complete record of the Association to be found anywhere. Broken files of the "Abstract of Proceedings" are held by several libraries (2). Fugitive references are to be found in the medical and sanitary journals of that day. In the early annual reports of the Ohio State Board of Health occasional references to the Association will be found (3). These references are so fleeting that they arouse a natural curiosity to know more about the Association.

The main reasons which brought about the organization of the Association seem to have been three in number. First, the deleterious effects, both socially and commercially, of recurrent epidemics with which the early settlers of Ohio had to struggle; second, the experience of the more populous centers in the state in attempting to curb epidemics and to improve insanitary conditions; and, third, the pressure from neighboring states which had established a state authority to bring order out of chaos.

Beginning with the establishment of the Northwest Territory in 1787 and continuing to the year 1852, the people of Ohio accepted the suffering and death which accompanied the regular appearances of epidemics with more or less fatalistic resignation. No one, not even the physicians, seemed to know what to do to combat them. The ideas, then prevalent, as to the causes of the swift and devastating rise and fall of the epidemic diseases were vague and confused. Practically all of the explanations had reference to the environment—exhalations from swamps or sewers; damp cellars; foul odors; filth; faulty drainage; faulty ventilation; and the changing climate.

In 1852, the Ohio General Assembly passed the first public health organization statute in the history of the State. It permitted cities to establish local boards of health if they so desired. Their chief functions were to abate nuisances and to enforce quarantine and isolation regulations. Further extension of this idea was made in 1875 when townships were permitted to establish local boards of health (4).

After the establishment of the Massachusetts State Board of Health in 1869 the idea of state control of health matters spread rapidly throughout the entire country (5).

Michigan, 1873; Kentucky, 1878; West Virginia, 1881; Indiana, 1881, and Pennsylvania, 1885, established boards modeled along the lines laid down in Massachusetts. Ohio, which did not establish such a board until 1886, was under continual criticism from these surrounding states, particularly West Virginia, because of the natural trend of travel to the east over the National Road and the consequent spread of epidemics from Ohio into that state.

Agitation for the establishment of a State Board of Health in Ohio came from the progressive physicians and laymen of the state. It began in the '70's. The proceedings of the Ohio State Medical Society show the sporadic outcroppings of this agitation during these years (6). No organized attempt at this time, however, was made to create public opinion to bring about such a board.

Early in the '80's R. Harvey Reed, M. D., began the presentation of the general subject of sanitation before the Mansfield Lyceum and Reading Circle. It was here that the idea of the Ohio State Sanitary Association was discussed for the first time. Dr. Reed became the moving spirit in the organization (7).

An editorial written by James F. Baldwin, M. D., editor of the *Columbus Medical Journal*, in January, 1884, gives the first announcement of the organization of the Association:

> There will be a Sanitary Convention in this city (Columbus), February 14 and 15. The convention will occupy two days, so as to afford time for the numerous papers that have been promised, and for action on the reports of important committees which will be appointed on the first day. A permanent organization is to be made which shall act as parent to local boards to be organized later in the year.
>
> This proposed organization is designed to take the place, so far as may be, of a State Board of Health, which Ohio ought to, but does not, possess. It is hoped and expected, however, that such a board will be the outgrowth ultimately of the present movement.
>
> A local association at Mansfield, headed by R. Harvey Reed, has initiated the present movement which bids fair to be a remarkable success (8).

In the same issue of the *Journal* the complete program for the two days' Convention is given. The announcement of the meeting is signed by Robert Harvey Reed, M. D., acting secretary, Mansfield, and James F. Baldwin, M. D., Columbus; Charles A. L. Reed, M. D., Hamilton; S. H. Smith, M. D., Warren; Elisha H. Hyatt, M. D., Delaware; and William W. Jones, M. D., Toledo, as a Counseling Committee (9).

The first meeting was held on February 14, 1884, at the Board of Trade, Columbus (10). The meeting was to have begun at 10:00 A. M., but was delayed in convening due to the difficulties delegates experienced in traveling caused by floods all over the state. Dr. J. F. Baldwin presided and welcomed the delegates to the city and the meeting. "The object of the meeting was to educate the people by the diffusion of a more thorough knowledge of the laws of health and the best means to be adopted for the prevention of all preventable diseases, and finally the securing of proper and wise legislation for the support of the same."

Wm. Morrow Beach, M. D., London, was elected temporary chairman and R. Harvey Reed, M. D., Mansfield, temporary secretary.

A Committee on Permanent Organization was then appointed consisting of: James F. Baldwin, M. D., Columbus; Xenaphon C. Scott, M. D., Cleveland; Elisha H. Hyatt, M. D., Delaware; Gustavus S. Franklin, M. D., Chillicothe; and Charles A. L. Reed, Hamilton.

The afternoon session was given over to Dr. X. C. Scott, who explained his bill "to establish Boards of Health and Medical Boards of Examiners and Licensers and regulating the practice of medicine and surgery in the State of Ohio and defining the powers and duties of such boards." A lively discussion then ensued, entered into by: Dr. E. H. Hyatt, Delaware; Dr. William J. Conklin, Dayton; Dr. John McCurdy, Youngstown; Dr. C. A. L. Reed, Hamilton; Dr. J. F. Baldwin, Columbus; Dr. R. D. Silver, Sidney; Dr. R. Harvey Reed, Mansfield; Dr. C. E. Beardsley, Ottawa; Dr. David H. Beckwith, Cleveland; Dr. H. J. Sharp, London, and Dr. Gustavus S. Franklin, Chillicothe.

An evening session was held in the hall of the House of Representatives, State House, at which time a general discussion was led by Starling Loving, M. D., Columbus, on the subject, "Resolved, That Legalized State Sanitation has Become a Necessity in the State of Ohio for the General Protection of its Citizens." Members of both houses of the State Legislature were especially invited.

On the morning of February 15, 1884, the report of the Committee on Permanent Organization was made and adopted.

For Officers:

President—Wm. Morrow Beach, M. D., London.
First Vice-President—Prof. Edward Orton, Columbus.
Second Vice-President—Prof. E. T. Nelson, Delaware.
Third Vice-President—Hon. L. D. Brown, Hamilton.
Secretary—R. Harvey Reed, M. D., Mansfield.
Treasurer—Prof. John Simpson, Mansfield.

For Committees:

Executive Committee which, ex-officio, includes all the presidents and secretary together with Starling Loving, M. D., Columbus; David H. Beckwith, M. D., Cleveland; William J. Conklin, M. D., Dayton; E. H. Hyatt, M. D., Delaware.

Committee on Publications—R. Harvey Reed, M. D., Mansfield; James F. Baldwin, M. D., Columbus; Geo. A. Collamore, M. D., Toledo.

Committee on Legislation—Wm. Morrow Beach, M. D., ex-officio, London; X. C. Scott, M. D., Cleveland; Charles L. Van Pelt, M. D., Toledo; and C. M. Finch, M. D., Portsmouth.

The Committee also reported on the Constitution and By-Laws as follows:

Name—The Ohio State Sanitary Association.

Object—The general advancement of sanitary science and the encouragement and promotion of local organizations throughout the state.

Members—Active, who shall form the body of the Association and shall be selected with special reference to their interest in sanitary and allied studies.

Honorary, who shall be selected with reference to their general interest only in the work in hand.

Meetings—At least once a year in the month of February and unless some other city is mentioned it will meet in Columbus.

The report was unanimously adopted.

The remainder of the meeting was given over to the reading of papers and discussion, the most important of which for our purposes were: David N. Kinsman, M. D., Columbus, "Some Reasons for the Establishment of a Board of Health;" Lewis C. Slusser, M. D., Canton, "Vital Statistics;" and Wm. Morrow Beach, M. D., London, gave his presidential address on "The Importance of Sanitation" (11).

The pertinent facts about the Association in subsequent years are briefly recorded together with the more important references.

Meetings (12)

1st —1884,	February 14–15.	Board of Trade, Columbus.
2nd—1885,	February 5– 6.	Board of Trade, Columbus.
3rd—1886,	February 24–25.	Board of Trade, Columbus.
4th—1887,	February 10–11.	Board of Trade, Columbus.
5th—1888,	February 9–10.	G. A. R. Hall, Toledo.
6th—1888,	November 14–15.	Assembly Room, City Hall, Canton.
7th—1889,	November 21–22.	Y. M. C. A., Dayton.

Presidents—Listed in year elected.

1st —1884.	Wm. Morrow Beach, M. D., London.
2nd—1885.	Edward Orton, LL. D., Columbus.
3rd—1886.	Henry J. Herrick, M. D., Cleveland.
4th—1887.	Prof. E. T. Nelson, A. M., Ph. D., Delaware.
5th—1888.	George C. Ashmun, M. D., Cleveland.
6th—1888.	David H. Beckwith, M. D., Cleveland.

Secretary

1st–7th—1884–1889.	R. Harvey Reed, M. D., Mansfield.

The main objective of the Association was reached when on April 14, 1886, the General Assembly of Ohio passed an "Act—To create and establish a State Board of Health in the State of Ohio" (13). Members of the first board appointed by Governor Joseph Benson Foraker on April 23, 1886, were:

W. H. Cretcher, M. D., Bellefontaine; T. Clarke Miller, M. D., Massillon; John D. Jones, M. D., Cincinnati; Simon P. Wise, M. D., Millersburg; David H. Beckwith, M. D., Cleveland; Thomas C. Hoover, M. D., Columbus; H. J. Sharp, M. D., London; and Hon. J. A. Kohler, Attorney General, ex-officio (14). On May 18, 1886, the permanent organization of the board was effected (15).

It will be observed that four of these appointees—Cretcher, Miller, Beckwith and Sharp—had been intimately identified with the Ohio State Sanitary Association. The other three appointees—Jones, Wise and Hoover—had been more or less interested in sanitary matters either locally or through the Ohio State Medical Society.

From the time the State Board of Health was organized until the demise of the Ohio State Sanitary Association on November 22, 1889, there appears to have been decided differences of opinion as to just what place the Association had in the public life of the state. There were also equal difficulties with respect to the Ohio State Medical Society.

An early evidence of this situation is contained in a resolution passed by the State Board of Health to the effect "that no papers shall be published in the Annual Report of this Board, except such as are ordered or approved for purposes of such publication by a majority of the members of the Board; and that any such paper shall be published over the signature of the writer, who is entitled to the credit of its production, as well as responsible for the statement of facts and opinions expressed therein." (16).

Another evidence is contained in the annual address of T. Clarke Miller, M. D., president of the State Board of Health, delivered in Columbus, November 17, 1887:

> The tendency to truculent criticism probably reached its climax when an eminent member of the profession, in a meeting of the Ohio State Medical Society, realizing his prominence and influence, bitterly assailed the personnel of the Board, and the motives which ruled in its selection. A resolution which appears in the "subsequent proceedings" indicates the profound impression made by the eloquent assailant of the Board (17).

The subsequent proceedings referred to Dr. H. J. Herrick, who offered the following resolutions, which, on motion of Dr. A. B. Carpenter, were adopted without discussion:

WHEREAS, our legislature has enacted statutes creating a State Board of Health, and in conformity with said enactment, His Excellency, Governor Foraker, has selected men of intelligence, professional skill and integrity for the several positions on said Board; therefore,

Resolved, That the State Medical Society cordially endorses the spirit and labors of the Board of Health in its arduous duties.

Resolved, that we approve, and will individually co-operate with the Board in its purpose to diffuse the principles of sanitary service, by all means proposed, especially by distributing tracts among the people and special meetings for the enlightenment of the people on subjects of sanitary science.

Resolved, That we recommend that the Legislature so increase their power that they can enforce provisions for the maintenance of public health.

Again:

The work of the "State Sanitary Association" is worthy of special consideration on account of its annual contribution of many valuable papers to current sanitary literature; . . .

It is hardly conceivable that self-aggrandizement should be the animus of any considerable proportion of the membership of this association; on the other hand, it cannot be doubted that, in the main, its members are actuated by a desire to promote the best interests of the people; this being the case, it is hoped that some satisfactory way may be found to place the more important of these papers within the reach of the people without expense to the writers . . . (18).

Steps were taken by the Association in 1887 looking toward making it an auxiliary to the State Board of Health. At the November 16, 1887, meeting of the State Board of Health, "a communication was presented from the Secretary of the Ohio State Sanitary Association relative to the publication of papers read before the Association in the annual report of the Board. Dr. Miller stated that at the last meeting of the Association . . . he had informed the Association . . . that the Board would be pleased to publish good papers not published elsewhere. Dr. Beckwith presented a communication from Prof. E. T. Nelson, President of the Sanitary Association. Dr. Nelson had been appointed to the Board in 1888 to succeed Dr. T. Clarke Miller, whose term expired, relative to a joint meeting of the Board and Association . . . " (19).

At the April 19th, 1889, meeting of the State Board of Health "a communication from Dr. Reed, Secretary of the Ohio State Sanitary Association, was read in which was given the action

of the Association in regard to making it auxiliary to the State Board of Health. The matter was referred to a Committee—Prof. E. T. Nelson and Dr. H. J. Sharp—with instructions to report at the next meeting of the Board." (20).

On June 19, 1889, Prof. Edward T. Nelson submitted a report from the committee appointed to consider the proposal to make the Ohio State Sanitary Association auxiliary to the State Board of Health. He said he had letters from a number of prominent members of the Association and all seemed to favor allowing the Association to come to an end as the State Board of Health could now carry on its work. The committee was not favorable to this proposition, but recommended that the State Board should pledge itself to carry on the work of the Association and hold one annual convention to which all sanitarians should be invited. Dr. W. H. Cretcher, M. D., Bellefontaine, spoke in favor of the report but did not consider it necessary for the Board to pledge itself to hold an annual convention, or to specify how it would carry on the work of the Association. With this amendment he moved the adoption of the report. The motion prevailed (21).

At the meeting of the Association on November 22, 1889, a committee consisting of T. Clarke Miller, M. D., Massillon; R. Harvey Reed, M. D., Mansfield; and Lewis C. Slusser, M. D., Canton, reported. A majority, consisting of Drs. Reed and Slusser, proposed the following resolution:

> WHEREAS, The Ohio State Sanitary Association was one of the pioneer organizations of its kind in this country and was organized nearly a decade of years since, for the purpose of "diffusing among the people a greater knowledge of the laws preventing all preventable diseases" and thus secure "proper and wise sanitation, systematically and scientifically administered," and
>
> WHEREAS, It has by these means been the active power in the creation of a State Board of Health, and has very materially aided in moulding public sentiment until better local sanitary laws have been enacted, and the organization of more effectual local boards of health in support of and in co-operation with the said State Board of Health has been accomplished all over our state; and
>
> WHEREAS, This "Veteran Volunteer Sanitary Association" of the State of Ohio has accomplished all the objects of its organization, and thus having fulfilled in an earnest, active, energetic and faithful manner the purposes for which it was created; therefore
>
> *Resolved*, That when all the business pertaining to the seventh annual meeting of this Association shall have been accomplished and the said Association is ready for adjournment, that the Ohio State Sanitary Association do then adjourn *sine die*.

A minority report was submitted by T. Clarke Miller, M. D., Massillon, who was chairman of the committee. He offered the following substitute resolution:

> WHEREAS, Independence is necessary to the efficiency of this organization,
>
> WHEREAS, "Support" has not been asked, and "co-operation" has not been thought of,
>
> *Resolved*, That "it would not be well for this Association to merge its efforts into a support of, and a co-operation with, the official forces of the State."

Upon debate George C. Ashmun, M. D., Cleveland, offered an amendment to the majority report which was accepted by Dr. Reed on the part of the committee. The amendment was:

> WHEREAS, The State Board of Health has provided for not less than two popular sanitary conventions each year; therefore be it
>
> *Resolved*, That we request the State Board of Health to arrange for not less than one meeting each year of the various local health officers of the state, and with this understanding, when all the business of the seventh annual meeting of the Ohio State Sanitary Association shall have been transacted, and it is ready for adjournment that it shall stand adjourned *sine die*.

In discussing the report and the amendment Dr. Reed said that "the prime object in organizing the Association had been to get at something definite and tangible in sanitary matters, and as such the result had been the organization of the State Board of Health. He now thought the objects had been accomplished and it was time to turn its labors over to the care and keeping of the Ohio State Board of Health." (22).

The majority report as amended was then unanimously adopted and a motion by Dr. Reed to adjourn *sine die* was carried. After which the members were taken in special cars to the Insane Asylum, where a reception and luncheon had been arranged for them.

And thus the Ohio State Sanitary Association passed into the limbo of all but forgotten episodes in the life of the people of Ohio.

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(22) Abstract of Proceedings Seventh Annual Meeting, pp. 26–7.

Ice

This intriguing book by Reginald Aldworth Daly, of Harvard, is the written material of the Silliman Lectures which he delivered at Yale University in 1934. The book is concerned with the last ice age, and describes the advance and retreat and various water bodies and changes of water bodies which have taken place during the ice age. There are seven chapters. The first considers the melted ice-caps and the present ice-caps. The second chapter discusses the recession of the Fennos Canadian ice; the third, the recession of the North American ice. In the fourth Daly considers the Mechanism of the Earth's deformation and recoil. Here are taken up the ideas of the effects of the great weight of ice on the geoid of the earth as it pushed down on the continents while the floors of the oceans were unloaded by a layer of sea water some 45 to 50 meters thick. Here we find the punching hypothesis favored over the idea of plastic recoil. The punching hypothesis makes use of a hinge zone at the margins of the ice. The supporting evidence for this hypothesis seems very strong. In chapter five the high sea levels of the Pleistocene are studied and in chapter six the low sea levels are taken up. Chapter seven, which is perhaps the most important problem, deals with Coral Reefs and the Ice Age. Here Daly gives very strong evidence in the Glacial Control Theory for the origin of our present coral reefs. This theory considers that the coral reefs got their start on wave cut platforms which were developed during the low Pleistocene sea levels and which grew up as the seas slowly filled. It is supported by numerous examples and it does not face the many difficulties of the classic theory of Darwin and Dana.

This is an exceedingly scholarly and readable discussion of the Ice Age. The illustrations are excellent, and with a few exceptions, opposite the pages where the discussion concerning them occurs. Some 29 tables summarize various types of data such as ocean temperatures and the like. Every one interested in Pleistocene history will get a new sense of proportions of this changing world. The numerous facts sorted out and used in support of the several theories, give an insight into the magnitude of the problems. There are geologists who will not agree with the author in various aspects of glacial history, but in spite of differences of opinion this is an extremely valuable work and will have many followers.

—Willard Berry.

The Changing World of the Ice Age, by Reginald Aldworth Daly. xxii+271 pp. New Haven, Yale Univ. Press, 1934. $5.00.

NOTES ON THE INFESTATION OF WILD BIRDS BY MALLOPHAGA[1]

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During the past five years while collecting birds for various scientific purposes, such as museum skins and mounts and parasite studies, records were kept on the infestation of these birds by Mallophaga. The birds were collected from various localities in Ohio, with the bulk of them taken at Buckeye Lake and in central Ohio, by the writer and others. For the opportunity to examine birds taken by other collectors I am indebted to Mr. Milton B. Trautman, formerly of the Ohio Division of Conservation, and to Mr. Charles F. Walker, of the Ohio State Museum. I thank Mr. Edward S. Thomas, of the Ohio State Museum, Mr. Milton B. Trautman, and Mr. Harold S. Peters, of the Bureau of Entomology, for their critical reading of this paper.

In this work a bird was considered to be infested with Mallophagan parasites if any stage in the life cycle of the insect was found on the bird. To date a total of 1,025 birds have been examined.

Nine of the 19 orders of birds are represented by these 1,025 individuals, of which the Passeriformes include more than half the total number. The nine orders are: Ciconiiformes, Anseriformes, Falconiformes, Galliformes, Gruiformes, Charadriiformes, Cuculiformes, Piciformes and Passeriformes. Table I gives the orders together with the individuals examined and the number infested.

The total infestation of the first eight orders was 178 birds out of 315 examined, or 56.5 per cent. The number of birds from each of these orders was admittedly too small to draw a definite conclusion. However, since these specimens were collected from many localities in Ohio during a five-year period, it would seem that a general idea of the amount of infestation might nevertheless be obtained.

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[1]Contribution Number 3, new series, from the Department of Zoology, Capital University, Columbus, Ohio.

It has been frequently stated that aquatic birds are more often parasitized than land birds, due to the more humid environment of these groups. If the following orders are considered to include aquatic birds, Ciconiiformes, Anseriformes, Gruiformes, and Charadriiformes, out of 97 examined, 56 individuals were found to be parasitized, or 57.7 per cent. If this is compared with the infestation of the entire first eight orders there is a difference of only 1.2 per cent in favor of the aquatic birds.

If we may consider the Falconiformes and Galliformes as large land birds, and compute the per cent of infestation in

TABLE I

Order	Individuals Examined	Individuals Parasitized	Per Cent of Infestation
Ciconiiformes	9	4	44.4
Anseriformes	21	16	76.1
Falconiformes	18	9	50.0
Galliformes	153	99	64.7
Gruiformes	5	5	100.0
Charadriiformes	62	31	50.0
Cuculiformes	4	2	50.0
Piciformes	43	12	27.9
Passeriformes	710	292	41.1
Total	1,025	470	Average 56.0

these groups, it is found that of 171 birds examined 108 were parasitized, or 63.1 per cent. This is 5.4 per cent more than in the aquatic group. Thus it would seem that the humidity factor is not as important as generally considered. Taking the Cuculiformes, Piciformes and Passeriformes as small land birds, from 757 of these, 306 were parasitized giving a percentage of 40.4. These figures show that in this case at least, the large land birds are more heavily parasitized than the other groups.

Another statement that has been commonly made in the literature is that gregarious birds are more often parasitized than non-gregarious birds. Of the orders represented, the Ciconiiformes, Anseriformes, Galliformes and Charadriiformes are the only ones which may be definitely considered gregarious. Combining these groups, of 245 birds examined 150 were parasitized, or 61.2 per cent. Considering the others non-

gregarious, 320 of 780 birds were parasitized, 41 per cent. These results tend to show that the gregarious habit is probably an important factor in the transmission of Mallophaga from host to host.

About 137 species of Passerines are found commonly in Ohio. Of this number, 710 individuals of 120 species, have been examined. In the Passeriformes the Hirundinidae, Corvidae, Laniidae, Sturnidae, Vireonidae and Icteridae show the heaviest infestation. Of these the Laniidae and Vireonidae are not gregarious. Computing the amount of parasitism in

TABLE II

Family	Individuals Examined	Individuals Infested	Per Cent Infestation
Tyrannidae	34	9	26.5
Alaudidae	25	3	12.0
Corvidae	16	10	62.5
Sturnidae	76	65	85.5
Icteridae	203	90	44.3
Fringillidae	105	39	37.1
Tangaridae	6	1	16.6
Hirundinidae	15	8	53.3
Bombycillidae	10	1	10.0
Laniidae	4	3	75.0
Vireonidae	16	8	50.0
Mniotiltidae	115	30	26.0
Motacillidae	1	0	none
Mimidae	10	6	60.0
Troglodytidae	15	6	40.0
Certhiidae	8	0	none
Sittidae	5	0	none
Paridae	13	1	7.6
Sylviidae	14	4	28.5
Turidae	19	8	42.1

the gregarious families, of 310 birds 173 were parasitized, or 56 per cent. Now computing the infestation of those families most often parasitized, but not gregarious: 19 birds, 10 infested, or 52.5 per cent. Results here again show that the gregarious habit tends to increase the infestation. Table II shows the numbers by families in the order Passeriformes.

From the data obtained in this study it would seem that the parasite life cycle extends over the entire year, since eggs and lice, or, eggs or lice, may be found on the same bird species during the entire year and is thus not seasonal. The birds examined during the winter months had few or no adults and

nymphs and usually many eggs, while the same species examined in early spring were found to have eggs and nymphs. In late spring and early summer the adults were numerous as were the nymphs and eggs, while in late summer and early fall the adults decrease in number and the eggs increase in abundance. It seems likely that the parasite cycle should be continuous throughout the year due to the comparative changelessness of the insect's environment. If, however, the weather was very cold the number of adults found on the birds was smaller. Probably in very cold weather even though the temperature of the bird remains practically the same the adult insects cannot live while the eggs carry the species over.

In as much as Mallophaga are seldom found living off the bodies of their hosts, the dispersal of the various species must depend upon bodily contact among the individual birds. However, the opportunities for bodily contact are not numerous. They are probably limited to roosting, nesting, copulation and from prey to predator.

There are a few records in the literature where Mallophaga have been found on birds of prey which undoubtedly came from the prey unless straggling occurred. It is believed this rarely occurs and no such cases were found in any of this work.

In the case of copulation the opportunity for transmission is relatively short and it is questionable whether many parasites are thus transferred. Also in birds that mate for only one nesting season during a year the transmission in this manner would be slight.

The opportunity for transmission in roosting is greater. Migration of lice from one host to another probably takes place, for undoubtedly there is often contact of the bodies of the various individuals. Kellogg states that he has found pelicans, cormorants and gulls roosting together on the "bird rocks" off Monterey, California, and that he has taken *Esthiopterum toxocerum* Nitz., a parasite of the cormorants, on the pelicans, as well as on the cormorants. But even on these ocean rocks, after frightening away hundreds of these birds he has looked in vain for Mallophaga that might be wandering from host to host.

Perhaps the greatest opportunity for transmission is from adult bird to young during feeding and brooding. Particularly during brooding the time of bodily contact is longest and the opportunity for the lice to find new feeding grounds is greatest.

It might be expected then that birds reared by foster parents would have the parasites of these parents. The cowbird (*Molothrus ater ater*) would furnish a case of this kind.

Since cowbirds are parasitic on about one hundred species of Passerine birds, it might be expected that Mallophaga of the cowbird's hosts would be found on cowbirds. In all the literature, prior to 1930, there is but one record of a louse taken from a cowbird, and that is Kellogg's record of *Philopterus transpositus* (Kell.) taken in Kansas in 1896. This species is a member of Piaget's group *forficulati*, which had up to that time been found only on the Psittacinae. This group of insects has a forcipated clypeal front. Kellogg's species has never been taken since to my knowledge.

One hundred fifty-five cowbirds have been examined; 71 or 45.8 per cent of which were infested with Mallophaga. Adult lice were found on 42 of these 71. The following five species of Mallophaga were taken:

1. *Menacanthus persignatus* (Kell.). Type host, California jay. This species has been taken from six American Passerines of which three are hosts of the cowbird.

2. *Myrsidea incerta* (Kell.). Type hosts, Goldfinch and russet-backed thrush. This species has been taken from nine Passerines, seven of which are hosts of the cowbird.

3. *Philopterus subflavescens* (Geoff.). Type host, European white wagtail. Also taken from some 80 Passerines, 70 of which are cowbird hosts.

4. *Degeeriella illustris* (Kell.). Type host, Red-winged blackbird. This species has been taken from six Passerines, of which five are cowbird hosts.

5. *Machaerilaemus laticorpus* Carr. Type host, a South American vireo It has also been taken from two Passerines, both of which are hosts of the cowbird.

Of these five species, *Philopterus subflavescens* and *Degeeriella illustris* were taken the most often. From the above records it seems that the parasites of the cowbirds fall into three general groups: (1) parasites that are found only on Icterid hosts; (2) parasites that lack host specificity and are found on many Passerines; (3) others that do not regularly parasitize cowbirds. The first two groups rank approximately equal in numbers, the third group being much the smallest.

Bagnall (1931) made a similar study on the Mallophaga of the European cuckoo which is also parasitic. He found

these parasites to be distinctly peculiar to the cuckoo and not to the various hosts of the cuckoo.

Some experiments in temperature response were performed on *Degeeriella vulgata* (Kell.) taken from an English sparrow. Ten adult lice of this species were kept in the laboratory on English sparrow feathers at a temperature of 38 degrees C. for ten days. The average temperature of the host of this louse is approximately 42 degrees C. Another group of 15 parasites of the same species was subjected to a temperature of 48 degrees C. This latter group showed marked irritation and all died within a few hours, while the controls lived 12 days at a temperature of 38 degrees C.

In collecting some of the birds in this work their temperatures were taken immediately after being killed. This was done by means of a special clinical thermometer which was thrust down the throat of the bird into the proventriculus. It is well known that the temperature of a bird varies four or five or more degrees between periods of rest and those of activity. Kendeigh and Baldwin in a study of nestling house wrens found the body temperature of these birds to vary as much as 8 degrees F. Simpson and Galbraith found the daily variation in temperature to be greater in birds of small size than in those of large size. Wetmore made a study of the temperatures of birds using the same methods as outlined above.

Wetmore's data on temperatures were used to check the amount of variation among the birds parasitized by certain species of Mallophaga. In this study *Philopterus subflavescens* (Geoff.) was taken from 30 different species of birds. The average temperatures of these hosts vary from 107 degrees F. to 110.2 degrees F., a difference of 3.2 degrees. Similarly the temperatures of the birds parasitized by *Degeeriella vulgata* (Kell.) vary from 106.9 degrees F. to 110.2 degrees, a difference of 3.3 degrees. The temperatures of the Anserine hosts of the three common duck infesting Mallophaga, *Trinoton querquedulae* Linn., *Anatoecus dentatus* (Scop.), and *Esthiopterum crassicorne* (Scop.) vary from 105.8 degrees to 107.9 degrees, a difference of 2.1 degrees. The difference in any of these cases is not more than 3.3 degrees, while other studies show variations in bird temperatures of as high as eight degrees, depending on rest and activity.

The average temperature of the cowbird is 108.2 degrees F. If this temperature is compared with the temperatures of the

hosts of the four principal parasite species mentioned above very little difference is found. The temperatures of the hosts of *Menacanthus persignatus* vary from 107.6° to 109.7°; those of *Myrsidea incerta* from 107.9° to 109.3°; those of *Degeeriella illustris* from 107° to 109.6°; those of *Philopterus subflavescens* were given above. These temperatures vary only 1.5° either way from that of the cowbird.

TABLE III

	Tyrannidae	Alaudidae	Corvidae	Sturnidae	Icteridae	Fringillidae	Tangaridae	Hirundinidae	Bombycillidae	Laniidae	Vireonidae	Mniotiltidae	Montacillidae	Mimidae	Troglodytidae	Certhiidae	Sittidae	Paridae	Sylviidae	Turidae
Menopon	x		x		x	x								x	x					x
Colpocephalum			x		x	x														
Menacanthus					x	x						x		x						x
Myrsidea			x	x	x	x		x				x		x	x					x
Machaerilaemus					x	x														
Eureum								x							x					
Ricinus	x	x				x			x		x	x							x	x
Philopterus	x	x	x		x	x	x	x	x	x	x	x		x	x			x	x	x
Degeeriella	x		x	x	x	x		x	x	x		x		x		x		x		x

Temperature may be a factor in determining host specificity for parasitic species, but the data so far accumulated is insufficient to draw any conclusions. Furthermore, by moving in close to the body of the host or out to the surface of the feathers, the parasite might make a suitable response to a variation in the host's temperature. It is probable then that temperature may be a relatively unimportant factor in host specificity.

Since more than half the birds examined in this study belong to the order Passeriformes, it is of interest to note the distribution of the parasite genera on the various bird families. Of the four Mallophagan families infesting wild birds all are found on the Passerines except Laemobothriidae. Of the Menoponidae the genera Menopon, Colpocephalum, Myrsidea, Eureum, Machaerilaemus and Menacanthus are found on this

bird order. Of the Ricinidae only the genus Ricinus is represented. The genera Philopterus and Degeeriella of the Philopteridae are found on the Passerines.

The genus Philopterus is present on 16 of the 20 families. On one of the remaining four families, the Sittidae, there were no lice taken. This genus includes more species than any other genus of the family. Degeeriella was found on 13 of the 20 families.

In the family Ricinidae the single genus Ricinus is found on but eight of the 20 families and of these eight it is found chiefly on the Turdidae and Fringillidae.

In the family Menoponidae, Menopon is found on seven of the bird families; Colpocephalum on three; Menacanthus on five; Myrsidea on nine; Eureum on two; and Machaerilaemus on two. Table III shows this relationship in graphical form.

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Blood Will Tell

The newer knowledge of the blood groups has developed so rapidly in the past few years that an up-to-date revision of this subject becomes essential. Dr. Wiener has supplied this need in his volume dealing with the blood groups and blood transfusion. All the practical applications of the groups are fully discussed: transfusion, clinical medicine, forensic medicine and anthropology. The M-N reactions are fully explained and their legal applications illustrated with case histories. The heredity of the M and N agglutinogens, as well as the older A and B antigens, is fully elaborated. The book is well illustrated with photographs and diagrams. Physicians, lawyers, biologists and anthropologists will find it essential to have this book on their shelves.—L. H. S.

Blood Groups and Blood Transfusion, by Alexander S. Wiener, M. D. xiv+220 pp. Springfield, Ill., Charles C. Thomas, 1935.

A NEW CHICKEN LOUSE (MALLOPHAGA: PHILOPTERIDAE) FROM THE CANAL ZONE

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Three lots of biting lice collected from the heads of domestic chickens in the Canal Zone were found to include an undescribed species with a peculiar, sharply angulated head. These lice are described below as representing a new species. It was surprising to find the new louse and the tropical head louse, *Lipeurus tropicalis* Peters,[2] in each of these three lots of material. The common chicken head louse, *L. heterographus* Nitzsch, found in many parts of the world, was not present. We have previously found that where the tropical head louse occurs it entirely replaces the common head louse and is the only louse found on the heads of the chickens, so this is an unusual record.

Lipeurus angularis n. sp.

Described from 13 individuals collected from the heads of domestic chickens in the Canal Zone as follows: One male and two females from Pedro Miguel, Canal Zone, 1931, by L. H. Dunn (Bishopp No. 18437), from chickens in the market; one male and six females from Mt. Hope, Canal Zone, May 18, 1934, by F. C. Bishopp (Bishopp No. 22104), from chickens in a farmer's flock; and two males and one female from Balboa, Canal Zone, May 19, 1934, by F. C. Bishopp (Bishopp No. 22105), from chickens in a poultry dealer's flock, the chickens having been raised in nearby Panama.

DESCRIPTION OF MALE

Head about three-fourths as wide as long, angulated in front, slightly wider across temples than before trabeculae. Temples broadly rounded, with one long and one very short seta on each side. Posterior edge of head only slightly concave. Eyes clear and protruding, with a rather short dorsal seta. Mandibles with expanded base and rather unusual size. Color light brown, with dark brown lateral borders, fading to almost colorless at forward edge of head. Clypeal suture with peculiar fold-like rounded points. Antennae about as long as head is wide, reaching, if extended backwards, to posterior edge of prothorax. First

[1]Contribution from the Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.
[2]Peters, H. S. *Entomological News*, Vol. XLII (1931), pp. 195–199.

segment enlarged, slightly longer than segments 3, 4, and 5 combined, and bearing no process. Segment 2 about half as long as segment 1; segment 3 extended into a dorsal inwardly projecting hook, as shown in Fig. 1a.

Thorax about three-fifths as long as the head, pale brown in color with dark brown lateral margins. Prothorax about two-thirds as wide as head, and about twice as wide as long, the sides only slightly diverging

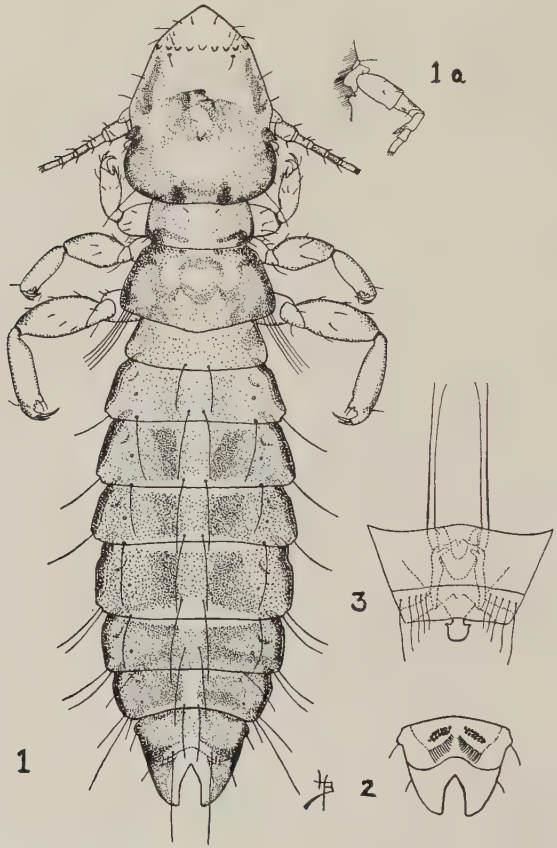

Fig. 1. *Lipeurus angularis* n. sp. Female, dorsal, × 38.
Fig. 1a. Antenna of Male, × 38.
Fig. 2. Posterior part of female abdomen, ventral, × 38.
Fig. 3. Male genitalia, dorsal, × 76.

posteriorly, the posterior edge slightly convex and with a seta at each latero-posterior rounded angle. Pterothorax slightly broader than head and half again as long as prothorax, sides diverging posteriorly, with rounded latero-posterior angles. Posterior edge slightly angulated on the abdomen, with a group of four long setae in a cleared area near each side. Legs pale with brown borders. Fore legs short, with the coxae

narrowly separated; middle and hind legs longer, hind legs longest and with widely separated coxae.

Abdomen of nine segments, elongate, widest at fourth segment, which is about one-third wider than the head. Ninth segment about three-fifths as wide as segment 8, with posterior edge slightly concave. From the sternum of the eighth segment there is a peculiar heavily sclerotized ball-like projection, studded with small spines on its surface, extending ventrally and posteriorly to the ninth segment, appearing as part of the genitalia and possibly functioning with it in copulation. Genitalia distinctive, edges of basal plate thickened and appearing as two rods extending forward into the sixth segment, endomeral plate horse-shoe-shaped, parameres separated and lying almost parallel, as shown in Fig. 3. Dorsal setae about the same as shown on the female in Fig. 1 and in Fig. 3. Light brown in color with dark brown pleurites forming a lateral band somewhat interrupted at the sutures. Lighter brown median markings, a clear space at the sutures, and a small clear area inside the lateral bands in which the small spiracles are situated on segments 2 to 7 inclusive.

DESCRIPTION OF FEMALE

Head slightly larger than in male. Antennae reaching, if extended backwards, slightly beyond posterior edge of head. Segment 1 swollen but equal in length to segment 2; segments 3 and 4 equal but shorter than 1 or 2; segment 5 slightly longer than 3 or 4.

Thorax and legs as in the male, except slightly larger.

Abdomen slightly longer and broader than that of the male. As shown in Fig. 1. Segment 9 deeply bilobed and bearing two combs of short setae ventrally, as shown in Fig. 2.

Average measurements in mm.

	Male Length	Female Length
Head	0.63	0.70
Thorax	.40	.45
Abdomen	1.22	2.62
Totals	2.25	2.77

Type Host.—*Gallus domesticus*, chicken.

Type Locality.—Balboa, Canal Zone.

Type Slide.—Cat. No. 50787, U. S. National Museum.

The *holotype* male and the *allotype* female on the type slide were collected from chicken at the type locality on May 19, 1934, by F. C. Bishopp (Bishopp No. 22105) and are deposited in the U. S. National Museum. The *paratypes* are in the collection of the Bureau of Entomology and Plant Quarantine.

This species is very unusual in the sharply angulated front of the head, the very peculiar ball-like projection from the eighth sternite of the male, and the very deeply bilobed ninth abdominal segment of the female. This bilobed segment may

function in some way with the ball-like projection of the male during copulation.

L. angularis is easily distinguished from other lice found on the chicken. The head is more pointed and the size is smaller than in *L. tropicalis*, which is found commonly on the chickens in many tropical countries. It is also easily distinguished from the common head louse, *L. heterographus*, by the angulated front, the genitalia, and the posterior part of the female abdomen.

NOTE.—Since sending this paper to the editor I have received the following paper: "On a New Mallophaga (*Lipeurus denticlypeus* n. sp.) From the Formosan Fowl," by Masaatsu Sugimoto, from "Taiwan no Chikusan" (Animal Industry in Formosa), Vol. II, December, 1934. The description of this new species is written entirely in the Japanese language. Sugimoto's *L. denticlypeus* appears to be very close to my *L. angularis* but is slightly larger in size. It will be necessary to compare specimens of the two species to determine whether or not they are the same. It is quite interesting to find such similar lice on the heads of domestic fowls on opposite sides of the world.—H. S. P.

Biology for Today

High School teachers of Biology will do well to acquaint themselves with this new text in the field. It was written, according to the author's statements, after long experience and considerable study in the mechanics of textbook composition. The discussions are about equally divided as to plant and animal material. The style is simple. The non-technical vocabulary is limited largely to the "seven-thousand level" of Thorndyke's word list. There is a conscious effort to present an analysis of the scientific method of procedure and thought, and to stimulate the student to follow it in working with problematic situations as presented in the text and illustrations. Various biological principles are stated and labelled as such, and the student is asked to state them from time to time for himself. The student is asked to state hypotheses relative to certain situations and then to test these in various ways.

Aside from a few unfortunate instances, the book is relatively free from teleological statements. The chapters on behavior, on health and hygiene, on the conservation of natural resources and wild life, and Biology for leisure time, are especially commendable.

A work book and a series of objective tests accompany the text.

—J. W. PRICE.

Biology for Today, by Francis D. Curtis, Otis W. Caldwell, and Nina Henry Sherman. xvi+692 pp. Boston, Ginn & Co., 1934.

ANTENNAL REGENERATION IN DAPHNIA MAGNA

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Antennal regeneration in Cladocera has been found to be rather variable. Przibram (1896, 1899) noted considerable variation both in amount and type of antennal regeneration in various species of *Daphnia* and *Simocephalus*. Kuttner (1913) found that antennal regeneration in *Daphnia magna* was extremely diverse. She noted that fully amputated segments never regenerated. Sciacchitano (1925) also pointed out that in *Ceriodaphnia pulchella* new segments of the antenna never formed. Setae were regenerated but never became as numerous, although often as large as the normal.

Recently Agar (1930, 1931) published some extensive researches on antennal regeneration in *Daphnia carinata* and *Simocephalus gibbosus*. His data show that the degree of variation in the amount of regeneration was high in spite of the fact that he limited the amputation to a specific level on a certain segment in each species and that the experimental conditions were very well controlled.

GENERAL OBSERVATIONS ON DAPHNIA MAGNA

When a ramus of an antenna is cut the distal end of the remaining stump turns brown within a few hours after the operation. The brown area is quite distinct from the rest of the stump. (Fig. 1.) The brown color is usually deepest at the proximal edge of the area. Late in the instar, provided the amputation was performed within the first half of the instar, a cleavage occurs between the brown area and the remainder of the stump. At ecdysis the brown material is cast off. During the next instar the injured ramus corresponds closely to that portion which was proximal to the brown area during the instar of amputation. A ramus may be cut in one segment and the brown area may extend down into the next. In such instances as well the ramus during the following instar always corresponds to that part which was proximal to the brown area.

A similar situation is found after the carapace is injured (Anderson and Brown, 1930; Anderson, 1933). When a small

area of the carapace is crushed with a ball-pointed needle a ring of brown material forms in the outer edge of the crushed area. At ecdysis this area is shed with the old chitin. During the next instar the wound corresponds closely to the area enclosed within and including the brown ring during the instar of injury. No part of the carapace need be removed to produce this phenomenon.

Further, no part of the antenna need actually be cut to cause the formation of brown material and the subsequent shedding of the portion of the antenna distal to and including

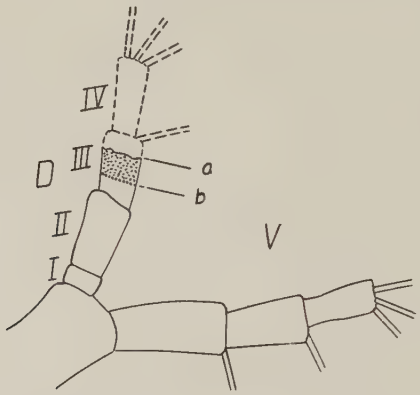

FIG. 1. An injured left antenna during the latter part of the first instar. A portion of the dorsal ramus was amputated early in the same instar. Line *a* denotes the level of amputation. The dotted lines represent the part removed. Line *b* denotes the level of injury. The stippled area between *a* and *b* is the brown portion—that injured by crushing in the amputation procedure.

the brown area. This was found by crushing part of the antenna sufficiently to injure the tissues but not break the chitinous cuticle. The area injured turns brown. The brown area together with the distal end of the antenna is cast with the rest of the old chitin at the next ecdysis. During the next instar the injured ramus corresponds closely to that part which was proximal to the brown area during the instar of injury.

Any amputation procedure involves the crushing of a part of the antenna before actual section is accomplished. Tissues proximal to the level of amputation are thereby injured. That part which is injured turns brown shortly after amputation. The brown color may be due to oxidized tyrosine in the clot of blood which forms in the injured portion (Pinhey, 1930).

The brown area probably corresponds to the necrotic area described by Agar (1930).

From the foregoing observations one may conclude that the injury is not limited to the level of amputation but extends to the proximal edge of the brown area. In making a quantitative study of the amount of regeneration the actual extent of the injury should be taken into consideration.

In order to determine the relation between the level of injury and the amount and type of regeneration the following series of experiments was performed.

MATERIALS AND METHODS

Females from a single clone of *Daphnia magna* Straus. were used. These were isolated within three hours after their release from the mothers and placed in a watch glass together with a few drops of culture medium. Just enough of a saturated solution of chloretone was added to render the animals immobile. Each animal was placed on its left side with the left antenna stretched out in front of the body. A specially ground steel needle was brought against the dorsal branch with enough pressure to sever it. The level of amputation was varied in each instance. After amputation each animal was placed in a vial containing approximately fifty cubic centimeters of fresh manure-soil medium (Banta, 1921). These were then allowed to remain at room temperature (18°–23° C.).

At least twelve hours after the time of amputation, but before the end of the instar, each animal was removed from its vial and placed in a watch glass together with a few drops of culture medium. Again just enough chloretone solution was added to bring about cessation of movement. After placing the animal on its left side with the injured antenna stretched out in front of the body, a camera lucida drawing of the amputated member was made. Care was taken to denote exactly the extent of the pigmented area. Immediately after making the drawing the animal was returned to its vial and allowed to remain until primiparous.

When the animal became primiparous the injured antenna was again drawn by following the same procedure as outlined above. Usually females bear their first clutch of eggs from six to eight days after their release from the mother when maintained at room temperature (Anderson, 1932). Those

which were not primiparous on the eighth day were discarded. This probably limited the data to those animals which passed through seven pre-adult instars or less.

From the first drawing the level of the injury was determined, i. e., the segment injured and the distance from the base of the segment to the proximal edge of the brown area. The obliquely bounded surfaces of the segments render measurement difficult. In each case the length was taken on the central axis of the segment. Uniformity of measurements was thus secured. From the second drawing, the length of the regenerated segment, the number of setae, and the length of the setae were determined. The length of the segment was taken in the same manner as in the first drawing.

Agar (1930) observed that the antennae change in size and shape only at ecdysis and immediately thereafter—they remain the same throughout the remainder of any instar. Drawings and measurements for any instar can therefore be made at any time during that period.

RESULTS AND DISCUSSION

The nature of regenerated antennae has been adequately described by Przibram (1896, 1899), Kuttner (1913), Sciacchitano (1925), and Agar (1930, 1931), and need not be detailed here. Regeneration is limited to the completion of the most proximal segment injured and the formation of new setae.

Agar (1930) considered only three measures of the amount of regeneration, namely: length of the antennal stump, number of setae, and length of setae. Of these he employed number and length of setae. In his estimation the stump was a poor criterion since regeneration involved only a slight growth of the operated segment. However, in *Daphnia magna* the volume of the regenerated material in the stump is much greater than that of the setae in most instances. On this basis one might conclude that the regenerated part of the stump would be a better criterion than that of the setae.

The amount of regeneration in the stump is not measurable directly. The segment in which regeneration has taken place may be looked upon as a product of both normal growth and regeneration. Normally a segment is about three times as long when an animal is primiparous as it is during the first instar. The difference between the length of the segment when an animal is primiparous and three times the length of the

uninjured portion during the first instar would then represent the amount of regeneration.

TABLE I

SUMMARY OF DATA ON LEVEL OF INJURY AND AMOUNTS OR REGENERATION
(Lengths are in μ)

LEVEL OF INJURY		REGENERATION				
Segment	Level in Segment	Length of Segment	Calculated Segmental Regeneration	Number of Setae	Total Length of Setae	Number of Cases
I	Base	0	.....	0.0	0.0	4
II	Base	0	.....	0.0	0.0	4
	1– 6	59 ± 15	50	1.25 ± .15	407 ± 44	4
	7–13	.....	.....	.....	.....	0
	14–19	136 ± 7	85	2.40 + .15	1020 ± 13	5
	20–25	127 ± 7	60	2.13 ± .16	770 + 60	8
	26–32	143 ± 6	53	2.33 ± .13	847 ± 64	6
	33–38	183 ± 10	77	2.50 ± .14	1127 ± 87	6
	39–45	169 ± 3	43	2.25 ± .28	910 ± 116	4
	46–51	199 ± 8	54	2.60 ± .15	1082 ± 15	5
	52–57	216 ± 14	51	3,00 ± .00	955 ± 83	3
	58–64	.....	.....	.....	.....	0
	65-70	229 ± 5	29	3.75 ± .27	1394 ± 141	4
	71–76	216 ± —	0	4,00 ± —	1210 ± —	1
III	Base	0	.....	2.50 ± .13	1094 ± 72	12
	1– 6	0 ± —	0	2.00 ± —	738 ± —	1
	7–13	73 ± 6	43	2.00 ± .00	1062 ± 36	7
	14–19	93 ± 5	45	2.14 ± .14	1196 ± 91	7
	20–25	112 ± 6	53	2.40 ± .15	1275 ± 53	5
	26–32	140 ± 10	53	3.33 ± .37	1553 ± 146	3
	33–38	134 ± 6	26	2.70 ± .18	1375 ± 95	7
	39–45	135 ± 11	6	3.00 ± .00	1566 ± 3	2
	46–51	172 ± 6	25	2.00 ± .00	1146 ± 35	2
	52–57	169 ± 8	0	2.00 ± .00	1177 ± 31	2
IV	Base	0	.....	2.47 ± .14	1273 ± 79	15
	1– 6	20 ± 5	11	1.80 ± .30	802 ± 153	5
	7–13	69 ± 6	39	1.67 ± .13	815 ± 64	6
	14–19	93 ± 4	45	2.50 ± .12	1299 ± 55	8
	20–25	108 ± 10	39	2.75 ± .15	1458 ± 31	4
	26–32	96 ± —	9	3.00 ± —	1476 ± —	1
	33–38	99 ± 8	0	2.50 ± .24	1247 ± 79	2
	39–45	127 ± —	0	1.50 ± —	1081 ± —	1
Terminal Setae	.....	.....	.....	2.75 ± .10	1578 ± 70	8

Table I summarizes the results. The level of injury is the level of the proximal edge of the brown material. Segmental

regeneration was calculated as proposed in the above paragraph. In those cases where the injury extended to the base of a segment that segment never regenerated. When the injury extended to the base of segment III or IV new setae were formed, but not when the injury reached the base of segment I or II. Removal of the terminal setae alone was followed by their regeneration. Whenever a part of segment II, III, or IV remained intact that segment exhibited regeneration and new setae were formed. Segment I was never regenerated nor were setae formed when the injury extended to that segment.

In general the length of the segment in which the regeneration occurred varied directly with the level of injury in the segment. The coefficients of correlation between the level of injury and the length of the segment were $+.76 \pm .04$, $+.80 \pm .04$, and $+.73 \pm .06$ for segments II, III and IV, respectively. The amounts of regeneration varied inversely with the level of injury except when the injury reached the base of a segment or only a very small part of the segment remained intact.

Setal regeneration appears to fall into a different category. Each segment seems to present a specific problem. In the case of segment II the number of setae formed appears to be directly related to the level of injury. The coefficient of correlation was $+.67 \pm .05$. The total length of the setae was not so well correlated, $+.34 \pm .09$. For segments III and IV the maximum number of setae and also maximum total length of setae occurred when the level of injury was just distal to the middle of the segment. The coefficients of correlation were $+.08 \pm .11$ and $+.39 \pm .11$ for number of setae and $+.31 \pm .10$ and $+.46 \pm .10$ for total length of setae for segments III and IV respectively.

The variations in the amount of regeneration reported by Agar (1930, 1931) are readily explainable. They are in all likelihood due to variations in the level of injury even though the level of amputation was kept constant. On the basis of the evidence presented in this paper one may alter Agar's (1930) statement from "the length of the segment left after operation is probably the most important single factor in determining the amount of regeneration" to—the length *of the uninjured portion* of the segment left after operation is probably the most important single factor in determining the amount of regeneration.

SUMMARY

The antennae of 150 female *Daphnia magna* were amputated at various levels during the early part of the first instar. In each case, within a few hours after amputation a brown pigment was deposited immediately proximal to the level of the cut. The extent of the brown area varied considerably. At the end of the instar the part of the antenna distal to and including the brown area was cast with the old chitin. During the next instar the antennal stump corresponded closely to that part of the antenna which was proximal to the brown area during the instar of amputation.

The amount of regeneration, as measured during the instar when the animals were primiparous, is qualitatively and quantitatively related to the segment in which the proximal edge of the brown area was located and to its level within that segment during the instar of amputation.

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WATER-VAPOR LOSS FROM PLANTS GROWING IN VARIOUS HABITATS[1]

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A plant's external and internal water relationships have been used extensively in explaining plant distribution. For more than a century botanists have measured transpiration from plants in various ways, resulting in a vast accumulation of data. However, most such measurements have been on plants growing in an environment quite different from that of their native habitats. It seemed desirable to make an extensive study of water-vapor loss from leaves of plants as they were growing in various plant associations. The habitats selected for this study were typical of the Deciduous Forest Formation of the Central States. These observations were made chiefly in Ohio and a few in the central part of Indiana, during the summers of 1927 to 1931 inclusive. The data presented were obtained from determinations upon one hundred and forty-eight species, belonging to sixteen plant associations.

The writer desires to take this opportunity to express his appreciation to Dr. E. N. Transeau, under whose direction this work was planned and carried out.[2]

METHOD USED

Determinations of the rate of water-vapor loss were made with standardized cobalt chloride hygrometric paper. This method was selected because it can be so readily applied to plants under field conditions. The measurements obtained are thought to be sufficiently accurate for problems in physiological ecology. The cobalt chloride method was originated by Stahl (10), later improved by Livingston (5), Bakke (1), Livingston and Shreve (6), and finally by Meyer (7). The hygrometric paper used in the following experiments was standardized quantitatively by Meyer's method.

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[1]Papers from the Department of Botany, The Ohio State University, No. 344.

[2]This paper represents a portion of the dissertation offered as a partial requirement for the doctorate degree from The Ohio State University.

The cobalt chloride hygrometric paper was prepared and mounted on narrow strips of celluloid as suggested by Meyer. The paper was cut into discs $^{15}/_{32}$ inches in diameter and fastened to each end and on the same surface of the strips, by means of gummed reenforcements for notebook paper. These held the hygrometric paper pieces in position with only the one surface exposed, which was to be placed next to the leaf to be tested, and the other surface could be seen through the celluloid. The strips were then folded along the short axis through the center. This made a clip which could be readily clamped to a leaf with the sensitive paper exposed to each epidermal surface. Small clamps (Dennison's Card Holder No. 42) were found satisfactory for holding the clip in place on the leaf.

Small desiccators for drying the clips were made from 100 cc. wide-mouthed bottles, stoppered with paraffined corks. Anhydrous calcium chloride was used as the desiccating agent. Cotton was placed on top of the calcium chloride to prevent the paper from coming in contact with the calcium.

It should be emphasized that the method does not measure transpiration as it normally occurs, but it does measure water-vapor loss under a standard set of conditions. For this reason the water-vapor loss as measured by the cobalt chloride paper has been called "standard water-vapor loss" by both Meyer (7) and Blaydes (2).

It may be well to point out some of the conditions of the artificial environment produced by the hygrometric paper clips. When a clip is applied to a leaf, light is removed from that small area under the clip into which water-vapor is lost by the leaf. Wind can have no direct effect on the small portion of the leaf being tested. All measurements may be reduced to a standard temperature by Livingston and Shreve's (6) method. Humidity of the atmosphere about the leaf has little if any direct effect, for almost as soon as the desiccated hygrometric paper is applied to the leaf, the small space between the clip and the leaf registers close to zero humidity. Therefore, the leaf surface being tested at first loses water-vapor to a nearly desiccated atmosphere. As the determination continues, however, this atmosphere becomes more and more humid. This introduces some error since the diffusion gradient is gradually decreased. The results of measurements of the water loss from a plant living in a very humid environment will deviate more from true transpiration rate than will the result of such measure-

ment upon plants in a dry environment. That is, the water-vapor loss as measured is more nearly a determination of what the plant would lose under the drier condition of the atmosphere. Blaydes (3) has shown that amounts obtained by the cobalt chloride hygrometric paper method and the weighing method do not necessarily coincide.

STANDARD WATER–VAPOR LOSS MEASUREMENTS

The objective of this work was to determine whether the standard water-vapor loss from plants of various associations was an adequate measure or an indicator of the habitat, as far as water relations were concerned. Livingston (5) and Bakke (1) concluded that the cobalt chloride hygrometric paper measurements might be used as indices of a given plant's water relations. Bakke also believed that the indices determined offered a comparatively simple and adequate method for classifying plant forms in a scale of xerophytism or mesophytism. Pool (8) studied forty representative species found in various plant communities from the short-grass mesas and plateaus east of Colorado Springs and up through the foothill bushlands to the subalpine forest associations, and the alpine meadows above an altitude of 12,000 feet. He determined the indices of "transpiring power," beginning with the most xerophytic forms and closing with the more mesophytic. In addition he made an anatomical study of the leaves of representative species and found that some species with strikingly xeromorphic leaves showed relatively high indices of "transpiring power." The indices for dominants and other species of various communities did not show very satisfactory differentiation of habitats. Wilson (12), working upon transplanted plants, found that the so-called xerophytes of Australia, "so long as the available water supply is adequate, have no special powers of accommodation," as far as transpiration is concerned. Meyer (7) studied eight woody species in Ohio and states "it is doubtful if the standard rate of water-vapor loss from the leaves of a species may be taken as an adequate criterion of the relative mesophytism or xerophytism of that species."

It will be noted that the data to be presented were obtained in habitats of entirely different plant formations from those studied by Livingston (5), Bakke (1) and Pool (8), but in the same as those of Meyer. Instead of isolated measurements

made on each plant as those of Livingston, Bakke and Pool and attempts at correlation with the habitat, these data represent a series of measurements made on each plant, at hourly intervals during a considerable part of the daylight period. It was expected that the more complete measurements would be more likely to show whether or not a correlation between habitat and rate of water-vapor loss existed.

It should be emphasized again that it is not likely that accurate comparisons of relative transpiration rates are possible between the plants growing on a dry, exposed hilltop and plants growing in a very moist habitat; or between herbaceous plants on the forest floor and exposed leaves of the tree cover. However, the standard water-vapor loss of plants of the two situations can be accurately compared.

In all cases the species selected for the tests are fairly representative of the given association. Leaves were selected which were apparently of the same age, size and condition. For each species, tests were made on five different leaves and the results averaged. Thus each figure on the following graphs represents the average of five approximately simultaneous measurements. The temperature was standardized to 20° C. for all the tests by Livingston and Shreve's (6) method. The standard water-vapor loss is given in terms of grams or fractions thereof, on the ordinates. The time representing daylight hours is shown on the abscissae.[3] The legend accompanying the graphs denotes the association in which the plants were growing, the date upon which the measurements were made, and the name of the plant. Usually two species were measured during a given day. These two were growing close together and living under very similar environmental conditions, except where type of root systems varied. Graphs for these may be identified by the dates given, if comparisons are desired. The nomenclature used is that of Gray (4).

An analysis of the data presented shows that in practically all species where no stomata are present on the upper surface of the leaves, the cuticular loss is 0.3 gram or less per hundred square centimeters of leaf surface per hour. This value is approximately the same whether the plant is growing in a dry habitat such as Oak-Cedar Cliffs association, in a Chestnut-

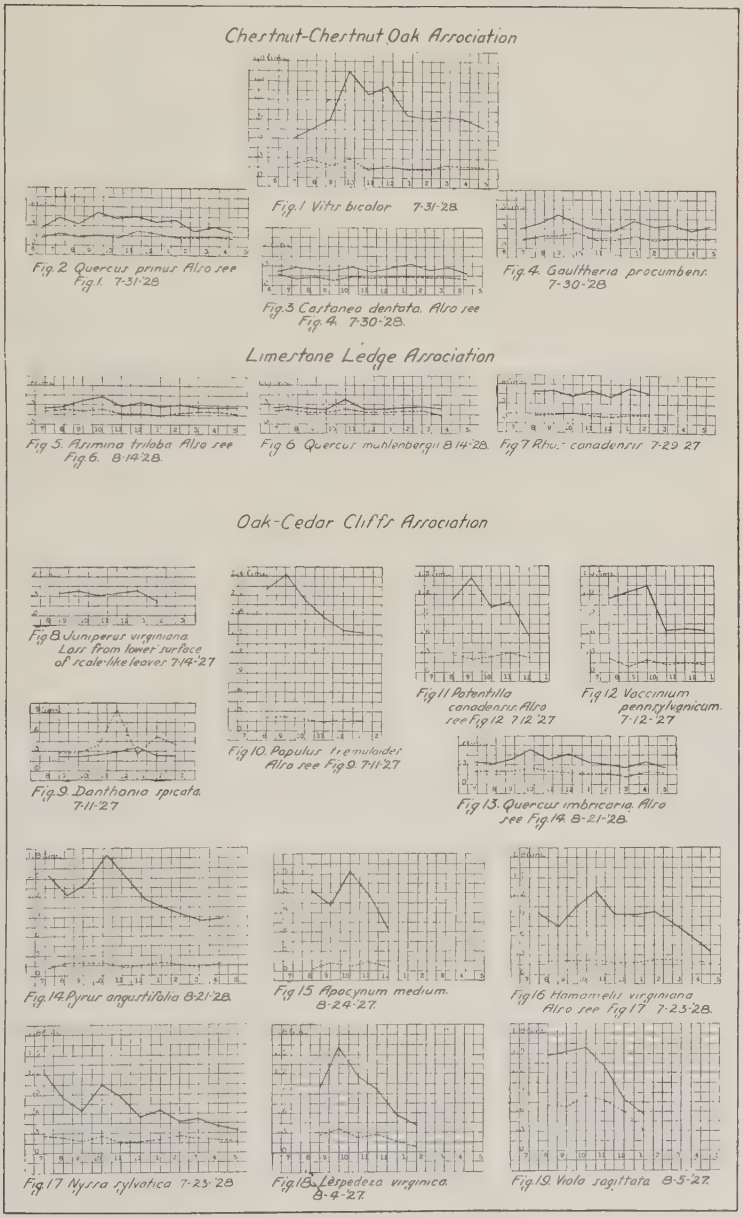
[3]Dotted lines of graphs (Figs. 1–119) indicate water vapor-loss from upper leaf surfaces, and solid lines loss from lower surfaces.

Chestnut Oak habitat, in a moist situation such as Buttonbush Swamp, or on a Sandbar.[4]

In the most xeric habitats studied, namely, the Chestnut-Chestnut Oak and the Limestone Ledge associations, the water-vapor loss from the surfaces bearing stomata was but little greater than stomata free surfaces. A decided exception is *Vitis bicolor* (Fig. 1), which was growing very near *Quercus prinus* (Fig. 2). *V. bicolor* is characteristic of the Chestnut-Chestnut Oak situation in Ohio. The measurements on the two plants were taken almost simultaneously (half hour apart). The water-vapor loss of the *V. bicolor* had a much greater maximum (1.7 g.), and in general, the whole water loss curve is greater than that of *Vitis cordifolia* (maximum, 1.1 g.) (Fig. 86), a typical River Bank form. Incidentally, a comparison of these two is also of interest since the leaves of *V. bicolor* are quite hairy while those of *V. cordifolia* are glabrous. This again emphasizes the fact that epidermal hairs are of no importance in retarding water-vapor loss, agreeing with Sayre's results for *Verbascum* (9). A comparison between the water losses of these two species of grape also indicates that a species typical of a dry habitat may lose water-vapor more rapidly than a typical species of a constantly moist habitat. Possibly internal conditions are of greater importance in determining the type of water loss than the amount of available water in the soil.

In the Oak-Cedar Cliffs association some comparatively high water losses are recorded. This particular region is underlaid with Ohio Black Shale from which considerable seepage occurs in deep ravines most of the year. *Populus tremuloides* (Fig. 10) showed an exceptionally high rate of water-vapor loss. *Quercus imbricaria* (Fig. 13) showed a very low rate. *Pyrus angustifolia* (Fig. 14) growing within a few feet of the oak was measured during alternate hours on the same day. A comparatively high rate of water loss was shown. *Danthonia spicata* (Fig. 9) is of interest since the greater loss is from the upper surface of the leaves. Loss from the lower surface is more nearly that found for cuticular surfaces. This species with *Juniperus* (Fig. 8) and *Quercus*, had the lowest rates of water-vapor loss among the twelve species studied. It is of

[4]For some associations, habitat names rather than standard plant association names have been used in order to indicate more specifically conditions in which the particular experimental plants were growing.


Chestnut-Chestnut Oak Association
Fig. 1 Vitis bicolor 7-31-28.
Fig. 2 Quercus prinus Also see Fig. 1. 7-31-28
Fig. 3 Castanea dentata. Also see Fig. 4. 7-30-28.
Fig. 4. Gaultheria procumbens. 7-30-28
Limestone Ledge Association
Fig. 5. Asimina triloba Also see Fig. 6. 8-14-28.
Fig. 6 Quercus muhlenbergii 8-14-28.
Fig. 7 Rhus canadensis 7-29-27
Oak-Cedar Cliffs Association
Fig. 8 Juniperus virginiana. Loss from lower surface of scale-like leaves 7-14-27
Fig. 9. Danthonia spicata. 7-11-27
Fig. 10. Populus tremuloides Also see Fig. 9. 7-11-27
Fig. 11 Potentilla canadensis Also see Fig. 12 7-12-27
Fig. 12 Vaccinium pennsylvanicum. 7-12-27
Fig. 13. Quercus imbricaria. Also see Fig. 14. 8-21-28.
Fig. 14. Pyrus angustifolia 8-21-28.
Fig. 15 Apocynum medium. 8-24-27.
Fig. 16 Hamamelis virginiana. Also see Fig. 17 7-25-28.
Fig. 17 Nyssa sylvatica 7-25-28
Fig. 18. Lespedeza virginica. 8-4-27.
Fig. 19. Viola sagittata 8-5-27.

interest to compare the loss from *Danthonia* with that of *Viola* (Fig. 19). These two plants grew side by side, and both are shallow-rooted forms.

The Cliff Crevice association types showed no great extremes of water-vapor loss. It is probable that such forms experience at least short extreme droughts due to the small accumulations of soil. Probably all species have been eliminated excepting forms which can withstand such dry periods.

Acer saccharum (Fig. 25), one of the dominants of the Beech-Maple habitat, showed a loss which might have been expected in a more xeric situation; in fact the curve is very similar to *Castanea* (Fig. 3), *Gaultheria* (Fig. 4), and *Quercus prinus* (Fig. 2), of the Chestnut-Chestnut Oak association. The similarity of the curves for *Asimina triloba* (Fig. 5), *Quercus muhlenbergii* (Fig. 6), and *Rhus canadensis* (Fig. 7), of the Limestone Ledge association, which was very dry, is also quite apparent. On the other hand, *Tradescantia pilosa* (Fig. 31) and *Smilax rotundifolia* (Fig. 30), of the Beech-Maple habitat, were in the group of highest water-vapor losing species found. *Ribes cynosbati* (Fig. 34), growing within a few feet of the others, showed a low rate of loss, approaching that of *Acer*. *Arisaema* (Fig. 28) and *Asarum* (Fig. 32) showed a water-loss curve which falls between the high and low water losers of the habitat. The graphs for these two are also strikingly similar. The loss curve for *Sanguinaria* (Fig. 33) is of interest in comparison to these last two since it is an herbaceous, early spring form and approaches *Acer* and *Ribes* in its type of water loss. The habitat of these Beech-Maple forms was very moist at the time measurements were made, due to a preceding thirty day period during which time rain fell almost every day. *Scrophularia* (Fig. 38), *Juglans* (Fig. 35), and *Aster* (Fig. 36), were growing in a more open place within the Beech-Maple habitat. Measurements on these species were made during a much drier period. These three showed water-loss curves having well marked periodicity with the maxima during the morning hours.

The Beech Forest association is very similar to the Beech-Maple community. Poorer drainage, probably, is the condition which eliminates the maples. Excepting *Fagus* (Fig. 41), all the species measured in this situation were forms not tested in the Beech-Maple situation. In general, the loss curves are similar to those of the related community. Growing within

Cliff Crevice Association

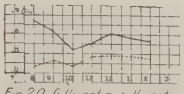


Fig 20 Sullivantia sullivanti
Also see Fig 22. 8-17-27

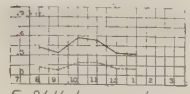


Fig 21. Hydrangea arborescens
Also see Fig 23. 8-18-27.

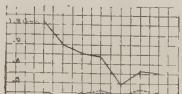


Fig 22 Silene rotundifolia
8-17-27.

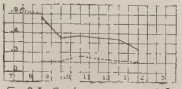


Fig 23 Asplenium pinnatifidum
8-18-27

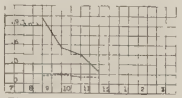


Fig 24 Pilea pumila
8-19-27

Beech-Maple Association

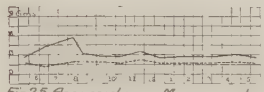


Fig 25 Acer saccharum Measurements made at height of twenty feet.
7-2-28

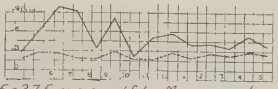


Fig 27 Fagus grandifolia Measurements made on same tree as for Fig 26, and at a height of thirty feet 7-19 28.

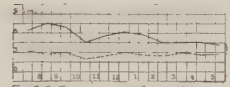


Fig 26 Fagus grandifolia Measurements made at a height of about four feet. 7-16-28.

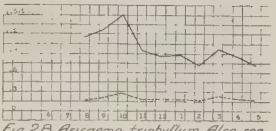


Fig 28. Aristaema triphyllum Also see Fig 29. 7-3-28.

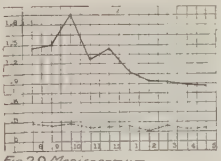


Fig 29. Menispermum canadense. 7-5-28.

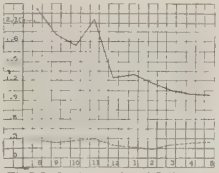


Fig 30. Smilax rotundifolia
Also see Fig 31. 7-6-28.

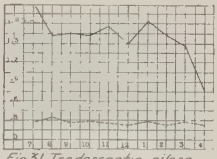


Fig 31 Tradescantia pilosa
7-6-28.

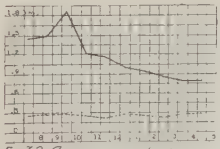


Fig 32 Asarum canadense
7-7 28

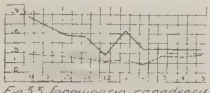


Fig 33 Sanguinaria canadensis
Also see Fig 34. 7-25-28.

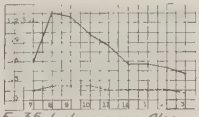


Fig 35 Juglans nigra. Also see Fig 38. 8-20-28.

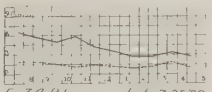


Fig 34 Ribes cynorbati 7 25 28

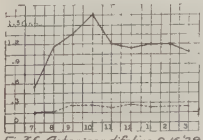


Fig 36. Aster cordifolius. 8-16-28.

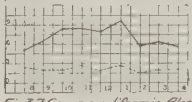


Fig 37. Carya cordiformis. Also see Fig 36. 8-16-28.

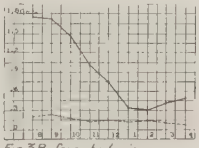


Fig 38 Scrophularia marilandica. 8-20-28.

a few feet of each other, the curves for *Fagus* and *Cornus* (Fig. 42) are similar. However, the maxima are rather widely separated. The curves for *Circaea* (Fig. 39) and *Actea* (Fig. 40) which grew side by side are also paralleled.

Among the species studied in a transition between Swamp Forest and Beech-Maple no unusual departures were found except among the Oaks. *Quercus alba* (Fig. 53) and *Q. rubra* (*borealis*) (Fig. 52) showed high maxima in the early morning. This did not appear previously in the species of *Quercus* from apparently drier habitats.

Species of the Swamp Forest habitat show a wide range of variation in rates of water loss. The highest loss observed (2.9 g. per sq. dm.) during this investigation was that recorded for *Lobelia cardinalis* (Fig. 62). *Quercus macrocarpa* (Fig. 56) and *Q. bicolor* (Fig. 55) showed water loss curves which were quite similar to oaks of more xeric habitats. *Quercus palustris* (Fig. 63) approaches the average for this association.

Graphs of several of the Flood Plain species are short due to a very rainy season, and to nights with low temperatures and heavy dews. This prevented the early morning measurements. *Fraxinus americana* (Fig. 68) and *Prunus serotina* (Fig. 69), growing side by side, with the measurements taken upon alternate hours, show similar curves, and *Pilea pumila* (Fig. 65) compared with the same species growing in the Cliff Crevice association (Fig. 24) shows a higher and a later maximum.

In the Mixed Mesophytic Forest, *Betula lenta* (Fig. 81) and *Cimicifuga racemosa* (Fig. 79) were the only species measured which showed a comparatively high water-vapor loss. The curve for *Fagus* (Fig. 83), *Oxydendron* (Fig. 80), *Kalmia* (Fig. 82), and *Rhododendron* (Fig. 78) approach those found commonly in drier situations. In south central Ohio, *Kalmia* is usually found on dry ridges. The water-vapor loss from it, however, is greater than from *Rhododendron*. Meyer (7) observed the same phenomenon. The time of greatest water loss for the *Rhododendron* occurred early in the morning, as previously reported by Meyer. *Kalmia* occurs abundantly on the very dry sandstone cliff-tops in southern Ohio, while *Rhododendron* is closely restricted to the moist ravines and north-facing slopes.

The River Bank forms show a rather wide range of fluctuations. They are more or less characterized by high, sudden maxima and rapid declines.

Beech Forest Association

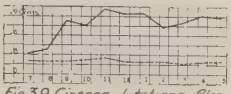


Fig. 39. Circaea lutetiana. Also see Fig. 40. 7-24-28.

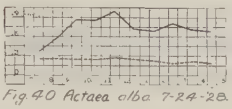


Fig. 40 Actaea alba 7-24-28.

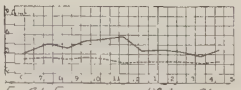


Fig. 41. Fagus grandifolia Also see Fig. 42. 7-20-28.

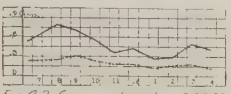


Fig. 42. Cornus florida 7-20-28

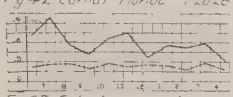


Fig. 43. Celastrus scandens Also see Fig. 44. 8-6-28.

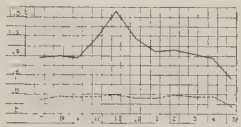


Fig. 44. Eupatorium urticaefolium villicaule. 8-6-28

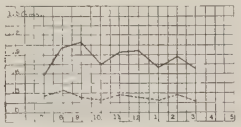


Fig. 45 Evonymus obovatus Also see Fig. 46. 7-26-28.

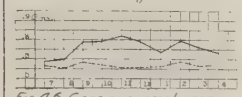


Fig. 46. Carpinus caroliniana 7-26-28.

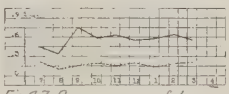


Fig. 47. Panax quinquefolium Also see Fig. 50 7-20-28.

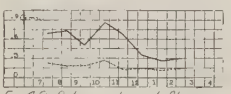


Fig. 48 Polygonatum biflorum 7-20-28

Transition from Swamp Forest to Beech Maple

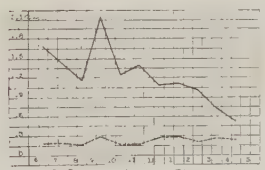


Fig. 49. Rosa setigera. Also see Fig. 50. 7-12-28

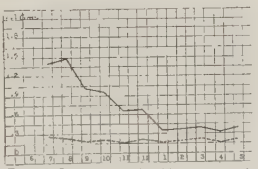


Fig. 50 Carya ovata Measurements made at height of about four feet 7-12-28

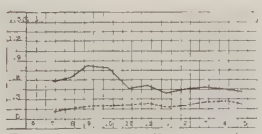


Fig. 51 Carya ovata Measurements made at a height of twenty feet 7-11-28.

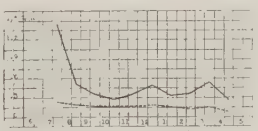


Fig. 52 Quercus rubra Also see Fig. 51 7-11-28

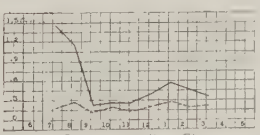


Fig. 53 Quercus alba Also see Fig. 54 7-13-28

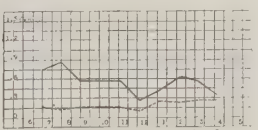
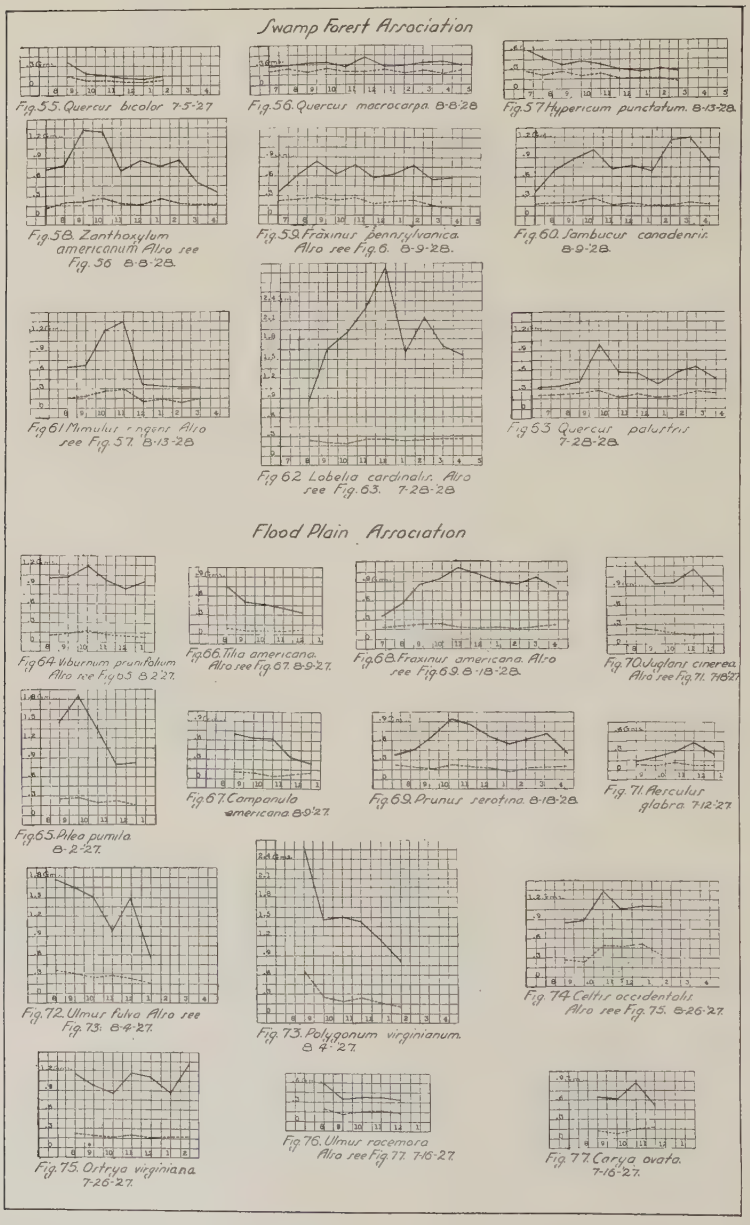
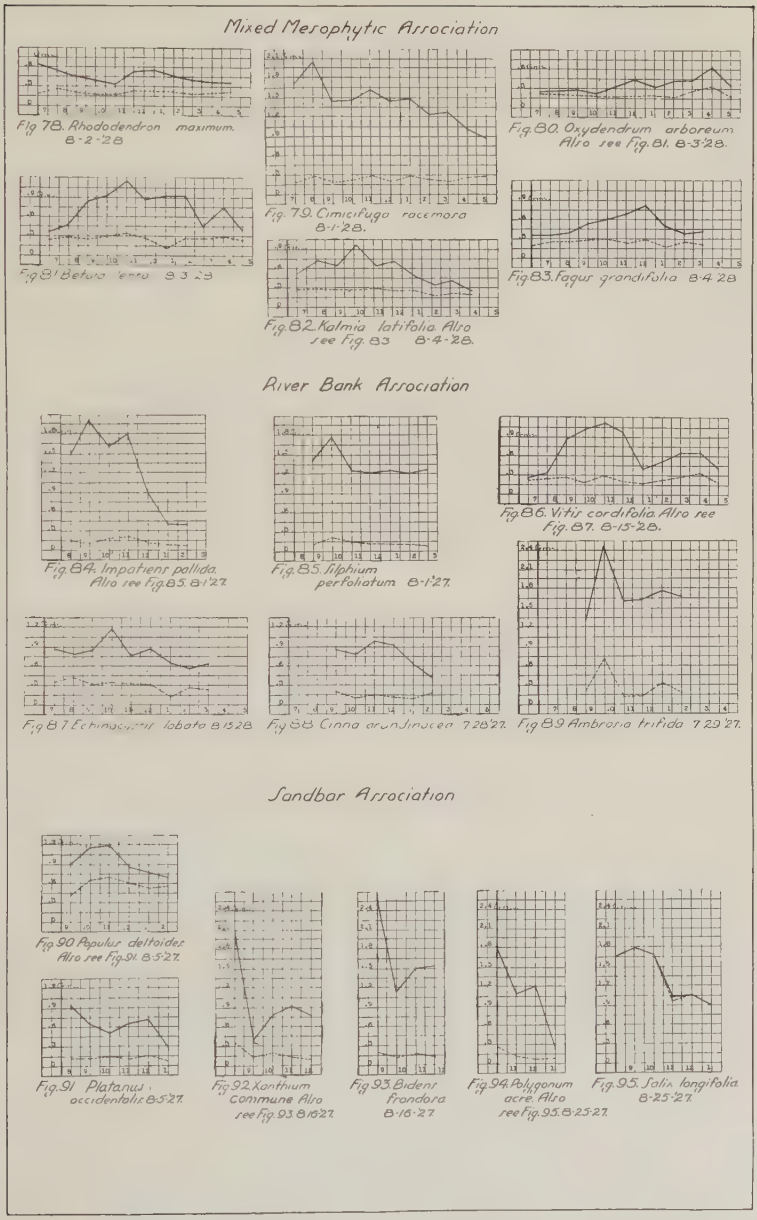


Fig. 54 Liriodendron tulipifera 7-13-28


Swamp Forest Association
Fig. 55. Quercus bicolor 7-5-27
Fig. 56. Quercus macrocarpa. 8-8-28
Fig. 57 Hypericum punctatum. 8-13-28.
Fig. 58. Zanthoxylum americanum Also see Fig. 56 8-8-28.
Fig. 59. Fraxinus pennsylvanica. Also see Fig. 6. 8-9-28.
Fig. 60. Sambucus canadensis. 8-9-28.
Fig. 61 Mimulus ringens Also see Fig. 57. 8-13-28
Fig. 62 Lobelia cardinalis. Also see Fig. 63. 7-28-28
Fig. 63 Quercus palustris 7-28-28.
Flood Plain Association
Fig. 64. Viburnum prunifolium Also see Fig. 65 8-2-27.
Fig. 66. Tilia americana. Also see Fig. 67. 8-9-27.
Fig. 68. Fraxinus americana. Also see Fig. 69. 8-18-28.
Fig. 70. Juglans cinerea. Also see Fig. 71. 7-18-27.
Fig. 65. Aleo pumila 8-2-27.
Fig. 67. Campanula americana. 8-9-27.
Fig. 69. Prunus serotina. 8-18-28.
Fig. 71. Aesculus glabra. 7-12-27.
Fig. 72. Ulmus fulva Also see Fig. 73. 8-4-27.
Fig. 73. Polygonum virginianum. 8-4-27.
Fig. 74. Celtis occidentalis. Also see Fig. 75. 8-26-27.
Fig. 75. Ortrya virginiana 7-26-27.
Fig. 76. Ulmus racemosa Also see Fig. 77. 7-16-27.
Fig. 77. Carya ovata. 7-16-27.


Mixed Mesophytic Association
Fig 78. Rhododendron maximum. 8-2-28
Fig. 79. Cimicifuga racemosa 8-1-28.
Fig 80. Oxydendrum arboreum Alro see Fig. 81. 8-3-28.
Fig 81 Betula lenta 8-3-28
Fig 82. Kalmia latifolia. Alro see Fig. 83 8-4-28.
Fig 83. Fagus grandifolia 8-4-28
River Bank Association
Fig 84. Impatiens pallida. Alro see Fig 85. 8-1-27.
Fig 85. Silphium perfoliatum 8-1-27.
Fig 86. Vitis cordifolia. Alro see Fig. 87. 8-15-28.
Fig 87 Echinocystis lobata 8-15-28
Fig 88 Cinna arundinacea 7-28-27.
Fig 89 Ambrosia trifida 7-29-27.
Sandbar Association
Fig 90 Populus deltoides Alro see Fig 91. 8-5-27.
Fig. 91 Platanus occidentalis 8-5-27.
Fig 92. Xanthium commune Alro see Fig 93 8-16-27.
Fig 93. Bidens frondosa 8-16-27
Fig 94. Polygonum acre. Alro see Fig 95. 8-25-27.
Fig 95. Salix longifolia 8-25-27.

The Sandbar habitat species show high maxima at an early hour. Perhaps the graph for *Salix longifolia* (Fig. 95) is of some interest in that the losses from the two leaf surfaces are practically the same.

Representatives of the Arbor-vitae Bog association (alkaline) showed a relatively low rate of water-vapor loss. The curves for *Thuja* (Fig. 97) do not represent the upper and lower surfaces of the scale leaves, but the loss as measured from the upper and lower surfaces of the scale covered twigs. The soil is saturated with water in this situation practically the whole year. Root systems in such situations are usually poorly developed, due to lack of oxygen. This may account for the low rates obtained. Whitfield (11) concluded from his experiments with potted sunflowers that "Transpiration was found to be highest in soils of medium water content, next in saturated soils, and lowest in soils with low water content." *Sambucus* in this habitat (Fig. 100) has about half the rate of water loss of the same species (Fig. 60), growing in the Swamp Forest association.

Only two species of the Sphagnum Bog association (acid) were measured. The short curves are rather unsatisfactory, but do show two very different types of water-vapor loss: *Decodon*-high (Fig. 102), *Eriophorum*-low (Fig. 103).

The Buttonbush Swamp habitat is characterized by its saturated soil throughout the year. The water loss curves for the species in this situation are all low and much the same as in the Arbor-vitae Bog. One of the lowest was *Iris versicolor* (Fig. 107). It is common knowledge that this species grows well in much drier situations in cultivation. *Rosa carolina* (Fig. 109) showed the minimum water loss in the group. Its maximum was only .62 gram per unit area. Lack of available water cannot be the cause since the soil was saturated. *Fagus* (Fig. 104) and *Benzoin* (Fig. 105) represent the Transition Zone from Buttonbush Swamp to Beech-Maple; the first being low, the second, medium high.

The above analysis of the data presented indicates that the standard water-vapor loss of a species cannot be taken generally as an indicator of its xerophytic or mesophytic character. To make a separation on this basis would place many species of hydrophytic forms in xerophytic habitats where they rarely or never occur and *vice versa*. This indicates that the rate of standard water-vapor loss may be an important quality of the

Arbor-vitae Bog Association

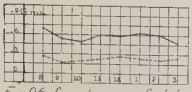


Fig. 96. Symplocarpus foetidus. Also see Fig. 97. 7-19-'27

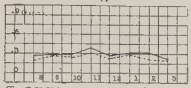


Fig. 97. Thuja occidentalis. 7-19-'27

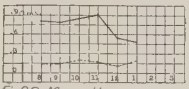


Fig. 98. Maianthemum canadense. Also see Fig. 99. 7-20-'27.

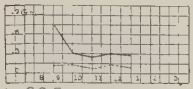


Fig. 99. Fraxinus nigra. 7-20-'27.

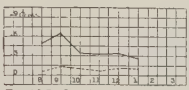


Fig. 100. Sambucus canadensis. Also see Fig. 101. 7-25-'27.

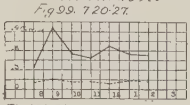


Fig. 101. Rhus vernix 7-25-'27.

Sphagnum Bog Association

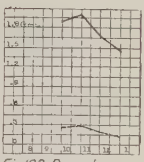


Fig. 102. Decodon verticillatus. Also see Fig. 103. 8-13-'27

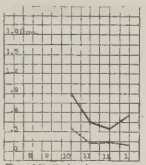


Fig. 103. Eriophorum virginicum. 8-13-'27.

Transition from Buttonbush Swamp to Beech-Maple Association

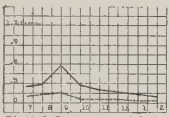


Fig. 104. Fagus grandifolia. 6-29-'27.

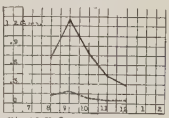


Fig. 105. Benzoin aestivale. 8-11-'27.

Buttonbush-Swamp Association

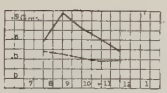


Fig. 106. Viola blonda. Also see Fig. 107. 7-8-'27.

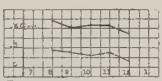


Fig. 107. Iris versicolor. 7-9-'27.

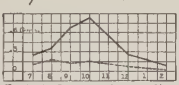


Fig. 108. Acer rubrum. Also see Fig. 109. 7-1-'27

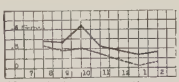


Fig. 109. Rosa carolina. 7-1-'27.

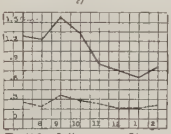


Fig. 110. Salix nigra. Also see Fig. 111. 7-2-'27.

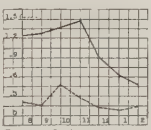


Fig. 111. Bidens connata. 7-2-'27.

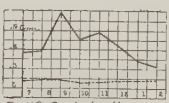


Fig. 112. Cephalanthus occidentalis. 6-29-'27.

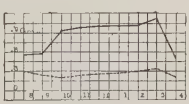


Fig. 113. Onoclea sensibilis. 7-6-'27.

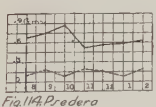


Fig. 114. Pedera quinquefolia. 6-30-'27

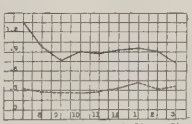


Fig. 115. Impatiens biflora. Also see Fig. 113. 7-6-'27

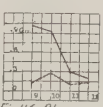


Fig. 116. Rhus toxicodendron. Also see Fig. 117. 7-8-'27.

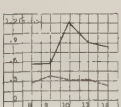


Fig. 117. Rubus allegheniensis 7-8-'27.

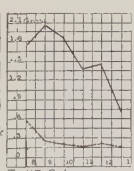


Fig. 118. Polygonum sagittatum. 8-16-'27.

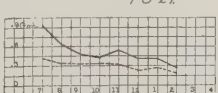


Fig. 119. Aspidium cristatum. 8-11-'27.

plant in some cases and not in others, just as light intensity is important in the distribution of some species and not in others.

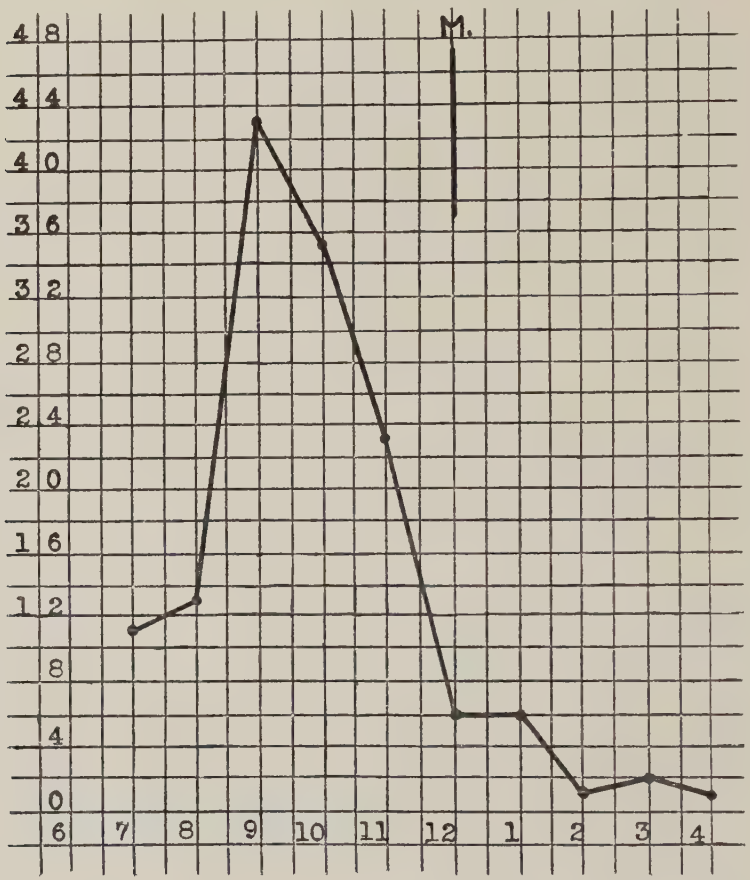


Fig. 120

FIG. 120. This graph shows the frequency of the water-vapor loss maxima for nine hours of the daylight period, collected from 148 plants growing in various habitats. Over 93% of the maxima occurred between 7:00 A. M. and 12:00 M.; 89% occurred between 7:00 and 11:00 A. M.; 52% occurred from 9:00 to 10:00 A. M. The maxima are given on the ordinate and time on the abscissa.

Early maxima are outstanding characteristics of most of the water-vapor loss graphs presented. From these maxima a a frequency curve (Fig. 120) has been constructed for nine hours of the daylight period.[5] Data from thirty other water-

[5]In order to make this graph more uniform, measurements occurring on the half hour have been placed with those of the following hour. Those falling between the hour and half hour have been placed with the nearest hour.

vapor loss curves, which have not been used otherwise in this paper, are included in this particular compilation. Plants from which these curves were made were cultivated varieties, weeds and additional wild forms used in investigating other water-vapor loss phenomena. Table I gives a list of these plants along with their time of maximum loss.

TABLE I

Name	Time of Maximum Water-Vapor Loss.
Asclepias syrica	11:00 A. M.
Canna flaccida	10:00 "
Growing in the greenhouse.	
Cannabis sativa	9:00 "
Bologna variety, staminate plant.	
Cannabis sativa	9:00 "
Bologna variety, carpellate plant.	
Cannabis sativa	10:00 "
Chington variety, staminate plant.	
Cannabis sativa	10:00 "
Chington variety, carpellate plant.	
Cannabis sativa	9:00 "
Commercial variety, staminate plant.	
Cannabis sativa	9:00 "
Commercial variety, carpellate plant.	
Cannabis sativa	9:00 "
Simple Leaf variety, staminate plant.	
Cannabis sativa	9:00 "
Simple Leaf variety, carpellate plant.	
Carica papaya	9:00 "
Growing in greenhouse.	
Commandra umbellata	9:00 "
Conocephalum conicum	10:00 "
Gametophyte.	
Diospyros virginiana	8:00 "
Measurements made July 10th.	
Diospyros virginiana	9:00 "
Same plant as above, but measured September 18th.	
Fraxinus caroliniana	11:00 "
Gossipium herbaceum	11:00 "
Melbane Big Bole Early Triumph.	
Helianthus tuberosus	10:00 "
Potted plant.	
Phaseolus vulgaris	1:00 P. M.
Measured August 20th.	
Phaseolus vulgaris	10:00 A. M.
Not the same as above. Measured August 16th.	
Phaseolus vulgaris	11:00 "
Seedling, measured September 3rd.	
Phaseolus vulgaris	10:00 "
Seedling, measured August 27th.	
Phoradendron flavescens	1:00 P. M.
Pyrus malus	9:00 A. M.
Grimes Golden variety. Measured July 10th.	
Pyrus malus	9:00 "
Same plant as above, but measured September 18th.	
Rhododendron maximum	12:00 M.
Leaves of second season.	
Sicyos angulatus	9:00 A. M.
Vaccinium pennsylvanicum	10:00 "

An analysis of this frequency curve of the water-vapor loss maxima determined for plants growing under various conditions, shows the percentage of maxima occurring between 7:00 A. M. to 12 M. to be over 93%; over 89% occurred between 7:00 to 11:00 A. M.; and 52% between 9:00 and 10:00 A. M. The greatest number of maxima (29%) occurred at 9:00 A. M. In other words, for over 93% of the plants studied, water-vapor loss maxima occurred before the period of maximum evaporation. An analysis of the maxima for each plant association shows that they are all quite variable within a given habitat, but that a majority in each location occurred before noon.

In practically all species studied, a distinct rhythm in the rate of water-vapor loss was very apparent. In some species the cuticular loss from the upper, stomata-free surfaces, showed slight rhythms.

It will be noted that measurements were made on *Fagus* (Figs. 27, 41, 83, 104) growing in four different habitats; *Sambucus* (Figs. 60, 100), *Carya ovata* (Figs. 50, 77), and *Pilea* (Figs. 24, 65), each growing in two different associations. As shown in these figures, the time of the maximum water-vapor loss, as well as the rhythms in general, varied from place to place.

Graphs are also presented showing the standard water-vapor loss from two different positions in the same tree. The species used were *Fagus* (Figs. 26, 27) and *Carya ovata* (Figs. 50, 51). The beech was measured at a height of thirty feet and again at approximately four feet. The lower position showed a higher maximum loss and a more pronounced rhythm. Measurements were made on the hickory at a height of twenty feet, and again at about four feet. The lower position showed a much higher maximum and, in general, a greater water-vapor loss.

SUMMARY

1. Determinations have been made of the standard water-vapor loss rates for 148 species of plants, representative of 16 plant associations located in the Deciduous Forest Formation of Ohio and Indiana.

2. Measurements were made, usually at hourly intervals, several times during the daylight period. This made possible the construction of curves showing diurnal variations in rate of water-vapor loss. This enables one to gain a more accurate idea of total daily standard water-vapor loss and its relation, if any,

to the habitat. Most other investigators of water loss have confined their determinations to isolated measurements. In many species the graphs show that the time of day may make a difference of 100% or more.

3. The standard water-vapor loss from herbaceous and low shrubs of the forest floor is often greater than the loss from lower leaves of plants forming the canopy. This conclusion is based upon comparisons of the loss of the forest floor types and the lower leaves of the canopy-forming trees. The atmospheric conditions about the lower leaves (three to five feet from the ground) and the herbaceous and low shrubby plants are probably not different.

4. This investigation indicates that the standard water-vapor loss of a species is not necessarily correlated with the position of a species in a relative scale of xerophytism, as indicated by the usual habitat of that species. Many xerophytic species exhibit relatively high rates of water-vapor loss, while *vice versa*, many mesophytic species have low rates.

5. Evidence is presented which indicates that plants growing in soil saturated with water and poorly aerated, such as in bogs and swamps, have lower rates of water-vapor loss than many growing in drier habitats, often approaching those of xeric situations. Internal physiological conditions and poorly developed root systems may be the causes.

6. For most species the time of maximum water-vapor loss occurs during the morning hours, long before the time of maximum evaporation. A frequency curve, constructed from these maxima, shows that 93% of the 148 plants studied, have their maximal water-vapor loss between 7:00 A. M. and 12 M., over 89% between 7:00 and 11:00 A. M., and 52% between 9:00 and 10:00 A. M. The greatest number of maxima occurred about 9:00 A. M., regardless of whether the habitats were wet or dry.

7. Pronounced periodicity of water-vapor loss occurred from the stomatal surfaces of nearly all species.

8. The majority of plants investigated showed a water-vapor loss of 0.3 g. per sq. dm. of leaf surfaces free of stomata.

9. When the same species was studied in two or more habitats the rate and the curves were usually different.

10. The lower leaves of *Fagus* and *Carya* had greater water-vapor loss than those at higher levels.

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Geologic Structures

In 1923 Bailey Willis wrote the first edition of "Geologic Structures" and used some 295 pages to describe them and to interpret them. The second edition appeared in 1929 and a third revised edition in 1934. This last edition gives within useful limits a complete treatment of the subject. In sixteen chapters and four appendixes the two authors consider geologic structure. The chapters in order take up Problems of Rock Deformation, *Mechanical Principles*, Stratified Rocks, Flexures and Folds, *Analysis of Folds*, Division of Rocks by Joints, Description of Faults, *Fault Types and Fault Displacements*, *Analysis of Faulting*, Structures of Igneous rocks. Structures of Metamorphic rocks, Physiographic Expression of Structure, Field Methods, *Graphic Methods*, *Practical Problems*, and Fundamental Facts and Concepts. The headings in italics are more technical than the others. The appendices are mainly technical discussions of various aspects of structure or experimental work on folds.

Students of geology will find considerable food for thought contained in the 509 pages. For those not primarily interested in structure it is an excellent hand book. Essentially it is a textbook for systematic study of structure.

—Willard Berry.

Geologic Structures, by Bailey Willis and Robin Willis. xviii+544 pp. New York, McGraw-Hill Book Co., 1934. $4.00.

THE ALIMENTARY CANAL OF *HARPALUS PENNSYLVANICUS* DEJ. (CARABIDAE: COLEOPTERA)

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During the latter part of September, 1932, a species of Carabidae, *Harpalus pennsylvanicus* Dej., was found in large numbers about one mile west of Worthington, Ohio. The insect was most common under small batches of hay in an alfalfa field. About fifty specimens were collected and taken to the laboratory for use in a morphological study of the alimentary canal. Half of the specimens were immediately killed and fixed in Kahle's (Dietrich's) fixative. After thorough washing, these insects were then stored in 70 per cent alcohol for future use. The remaining twenty-five specimens were placed in a small screen cage about two feet square and covered with leaves at the base of a large sycamore tree. This procedure permitted the use of live specimens during the entire winter.

The figures herein presented were reproduced from material stained with Haemalum and Fast Green. This combination served very well to differentiate the cell layers and the nuclei, but in some sections the cell walls were not distinct. Delafield's haematoxylin and eosin were tried in various combinations but with results often less satisfactory.

This work was done at the Ohio State University under the supervision of Dr. Clarence H. Kennedy, to whom the writer is grateful for advice and criticism during the course of study.

GENERAL DESCRIPTION OF THE ADULT

The beetle is an oblong, robust species varying in length from 13–15.5 mm. The back is uniformly black and moderately shiny while the lower surface is dark reddish brown to piecious. The antennae are reddish yellow. The thorax is broader than long, with the base as wide as the elytra.

The Alimentary Canal

The total length of the canal is approximately 21.5 mm. The cellular structure indicates that it is divided into three main divisions. The anterior portion, *fore-gut*, and the posterior portion, *hind-gut*, are continuations of the body wall. These two divisions are connected by a

central division, *mid-gut*, which is entirely different in cellular structure. The exact location of the main divisions and the subdivisions of the alimentary canal depends largely on the amount of food an individual has taken and the amount of adipose tissue in the body. In general, however, the fore-gut is approximately 8.5 mm. in length and occupies the position shown in Fig. 1, extending along the ventral part of the body to the first abdominal segment. The mid-gut, averaging 6.5 mm. in length, begins at the oesophageal valve and joins the hind-gut in the posterior half of the third abdominal segment. The hind-gut is approximately 6.5 mm. long, extending from the Malpighian tubules to the anal opening.

FORE–GUT

The fore-gut, measuring 8.5 mm., consists of the *buccal cavity*, *pharynx*, *oesophagus*, *crop*, *provintriculus*, and *oesophageal valve*. This division begins with the buccal cavity at the anterior end and extends to the oesophageal valve at the posterior end. The pharynx is very small and short, measuring less than .4 mm. in length. The oesophagus is approximately 4.5 mm. long, extending from the pharynx posteriorily to the crop. At this point the canal enlarges to form a bulb-like organ, the crop, which is about 3 mm. long and in most specimens occupies a position in the hind part of the metathorax and first abdominal segment. At the posterior end and somewhat from the side of the crop the provintriculus connects the crop to the mid-gut. The provintriculus is .5 mm. in length and is hardly distinguishable except by cellular structure.

In general the histological structure of the fore-gut is similar to that of the body wall. A cross-section of this part of the canal shows the following cellular layers: (1) a chitinous inner lining, *intima;* (2) an *epithelium* of hypodermal cells; (3) a layer of *longitudinal muscles;* (4) a layer of *circular muscles*, and (5) an inclosing membrane of *connective tissue* (*Peritoneum* with some writers). This arrangement of the cellular layers is continuous in the fore-gut, but in some sub-divisions a layer may be more pronounced than in others.

The intima or chitinous lining of the digestive cavity is distinct through the fore-gut. Figs. 2 and 5 show that in the oesophagus it is comparatively thin while in the provintriculus the layer is much heavier and is densely covered with spine-like projections. The large longitudinal folds are provided with secondary folds having serrated margins.

Epithelium is present in each of the subdivisions. In the oesophagus, however, the cells are hardly visible at a magnification of 440 times, while in the provintriculus they are outstanding under such magnification.

The longitudinal muscles of the fore-gut are in longitudinal folds which vary in number along the oesophagus. In the provintriculus they are definitely arranged into four distinct folds, the surface of which comprises approximately one-half the lining of the provintriculus.

The circular muscles vary from a few scattered strands around the walls of the oesophagus to a layer several cells in thickness in the provintriculus. The heavy layers of longitudinal and circular muscles in the provintriculus indicate that it is a powerful organ in the process of digestion even though it is relatively small.

A layer of connective tissue surrounds the fore-gut. In many cases this tissue is torn from the wall of the digestive tract in the process of sectioning.

The oesophageal valve, Fig. 6, marks the posterior end of the fore-gut. This valve consists of a heavy circular fold of the epithelium which extends slightly into the anterior end of the mid-gut. It is richly supplied with circular and longitudinal muscles, the position of which, in relation to the fore-gut, is completely reversed in this part of the canal.

MID–GUT

The mid-gut extends from the oesophageal valve at the anterior end to the pyloric valve at the posterior end. When in its natural position it is spiral shaped with the posterior end near the center of the body. It is approximately 6.5 mm. long and is divided into two slightly different parts, the *anterior mid-gut*, which is 1 mm. in length, and the *posterior mid-gut*, which measures 5.5 mm. This division of the canal is densely covered with *crypts* which are all uniformly perpendicular to the walls of the gut. Fig. 1 shows the uniformity which is expressed at the expense of the perpendicular arrangement. On the surface of the anterior mid-gut, the crypts are much larger than those on the posterior mid-gut.

There are four layers of cells in the mid-gut arranged in the following order, beginning with the lining of the digestive cavity (Fig. 4): (1) epithelial cells, (2) circular muscles, (3) longitudinal muscles, and (4) connective tissue. The epithelial layer is distinct and is locally crowded into folds between the bases of which it is evaginated into crypts that cover the surface of the mid-gut. This arrangement of cells greatly increases the surface of the epithelium in this division of the canal. The cells of this layer vary from a rectangular form in uncrowded conditions to a long club-shaped form where the cells are more congested.

Circular muscles of the mid-gut vary in thickness from one to three cells, and compared with circular muscles of other parts of the intestine, they are exceedingly minute.

The longitudinal muscles do not form a continuous layer around the mid-gut. Muscle strands that are present are often barely visible when magnified 950 times.

A thin layer of connective tissue surrounds the mid-gut (Fig. 4).

The crypts which cover the surface of the stomach are composed of large distinct cells which are continuous with the epithelium of the mid-gut. At the tip of the crypts are located the nidi which, according to Comstock, are areas of cell reproduction and rapid growth (Fig. 10).

HIND–GUT

The hind-gut is 6.5 mm. in length and consists of the *pyloric valve*, *Malpighian tubules*, *ileum* and *rectum*. The anterior end is marked by the entrance of the Malpighian tubules. The four tubules enter the digestive tract separately, but when viewed from the exterior they appear to enter in pairs. They are approximately the same length as the digestive tract and are thoroughly woven into the tracheae and

fatty tissue that surround the walls of the mid-gut. The ileum is 4.5 mm. in length and is comparatively uniform in size to a point near the junction of the rectum, where the size is doubled. The rectum is cone-shaped, tapering to about .3 mm. in diameter at the anal opening. The six rectal pads are located near the anterior end and are plainly visible through the transparent walls of the intestine (Fig. 1).

Beginning with the lining of the digestive cavity the cell layers appear in the following order: (1) intima, (2) epithelium, (3) longitudinal muscles, (4) circular muscles, (5) longitudinal muscles, and (6) connective tissue.

The pyloric valve is formed by a circular arrangement of enlarged areas of epithelium of the hind intestine (Figs. 7 and 8). Between these areas the malpighian tubules make their entrance to the digestive tract.

When viewed in cross-section the Malpighian tubules consist of a cellular layer varying from a large number of small cells at the open end to about ten large cells at a more distal point. The inner lining of the tubules is composed of *pore canals* which give this tissue a striated appearance when viewed in cross-section (Fig. 11). The large cells are surrounded by an inclosing layer of connective tissue which contains an occasional large cell which, it is believed, may serve as circular muscle.

The intima is evident throughout the hind intestine and is about equal in thickness in each subdivision.

The epithelium is continuous in the hind intestine. In the ileum it surrounds the large groups of longitudinal muscles. It varies in thickness along the tract, and in the rectal pads the layer is composed of two types of cells, the large rectangular cells of the pads and the normal epithelial cells at their base.

The longitudinal muscles are in two layers which are separated by circular muscles. The layer adjacent to the epithelium is grouped into six large folds of epithelial tissue. The second layer of longitudinal muscles is also in groups and is immediately surrounded by the connective tissue (Fig. 12).

The circular muscles are large and numerous in the ileum, while near the rectal pads the layer is reduced to scattered large cells.

The hind intestine is surrounded by a layer of very thin connective tissue (Figs. 7 and 12).

At the anterior end of the rectum the walls approach a transparent condition. As a result of this condition the rectal pads are subject to examination from the exterior. In an alternating arrangement three of these pads are more anteriorly placed than are the other three (Fig. 1).

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EXPLANATION OF PLATES

Plate I

Fig. 1. Dorsal view of alimentary canal arranged to show the relative proportion and position of the parts. (× 10.)
Fig. 2. Cross-section of the oesophagus.
Fig. 3. A part of the same section as Fig. 2 when under much greater magnification.
Fig. 4. Cross-section of the posterior mid-gut. Note crowded condition of the epithelium and presence of folds.

Plate II

Fig. 5. Cross-section of the provintriculus. Note the heavy chitinous intima and spine-like projections.
Fig. 6. Longitudinal section of the provintriculus and oesophageal valve. Note change in position of muscle layers.
Fig. 7. Longitudinal section of the pyloric valve and part of ileum. Note change in position of muscle layers at valve. Two layers of longitudinal muscle are present in the ileum, but this section illustrates only one.
Fig. 8. Cross-section of the pyloric valve showing the entrance of the Malpighian tubules.

Plate III

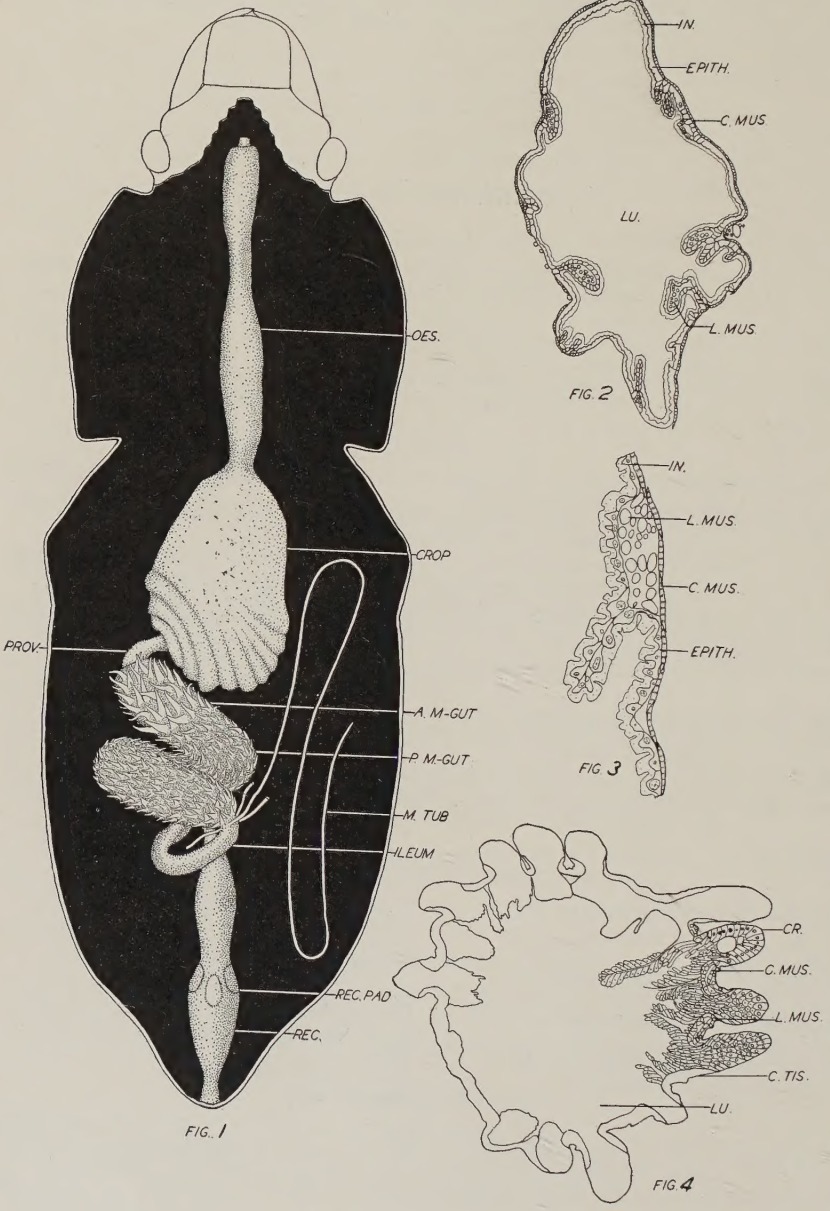
Fig. 9. Cross-section of the rectum showing the rectal pads.
Fig. 10. Longitudinal section of a crypt showing the nidus and globules of secretion.
Fig. 11. Cross-section of the Malpighian tubule near distal end.
Fig. 12. Cross-section of the ileum. Note the heavy layer of circular muscles and the two layers of longitudinal muscles.

SYMBOLS USED IN PLATES

A. M.—Anterior mid-gut
C. M.—Circular muscle
CR.—Crypt
C. TIS.—Connective tissue
EPITH.—Epithelium
EPITH. C.—Epithelial cells
IN.—Intima
L. MUS.—Longitudinal muscle
LU.—Lumen of intestine
M. TUB.—Malpighian tubule
OES.—Oesophagus
O. V.—Oesophageal valve
PROV.—Provintriculus
P. M. GUT—Posterior mid-gut
P. CANAL—Pore canal
P. V.—Pyloric valve
REC.—Rectum
REC. PAD—Rectal pad
SEC.—Secretion of crypt

Harpalus pennsylvanicus Dej.
F. B. Whittington

PLATE I



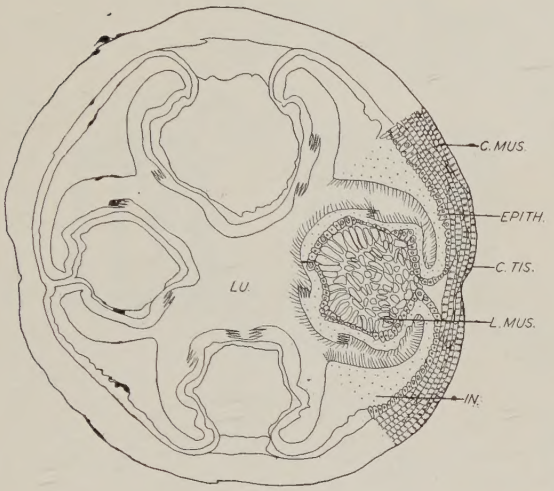


FIG. 5

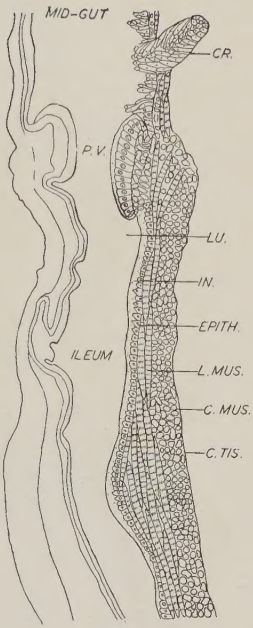


FIG. 7

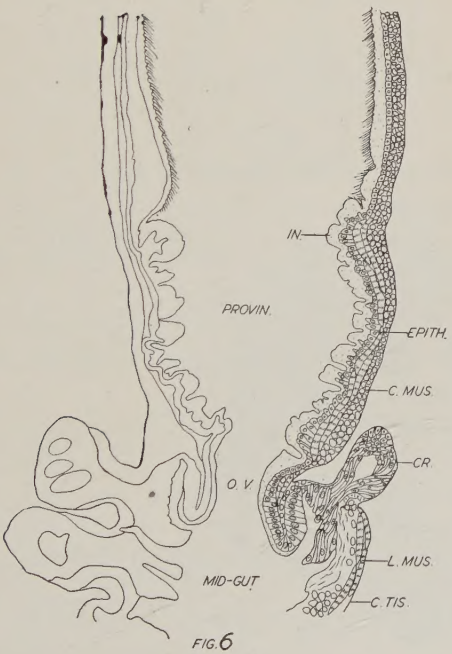


FIG. 6

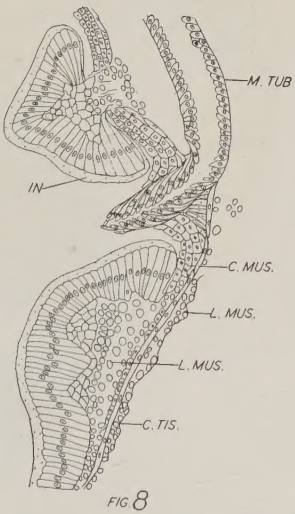


FIG. 8

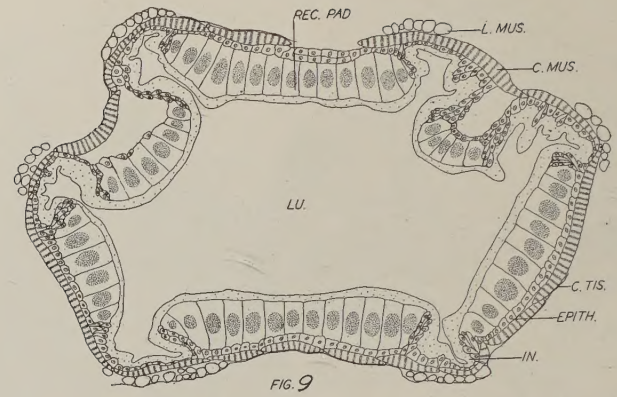


FIG. 9

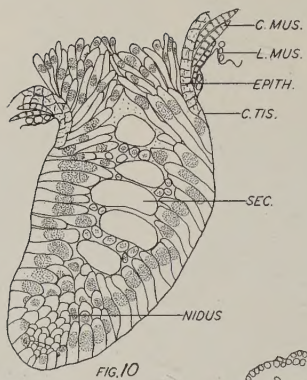


FIG. 10

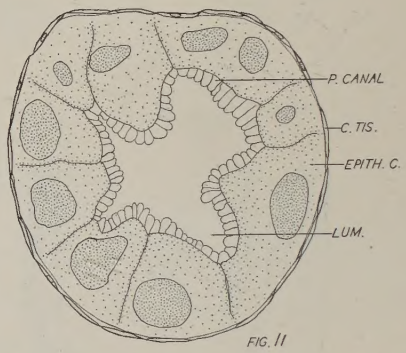


FIG. 11

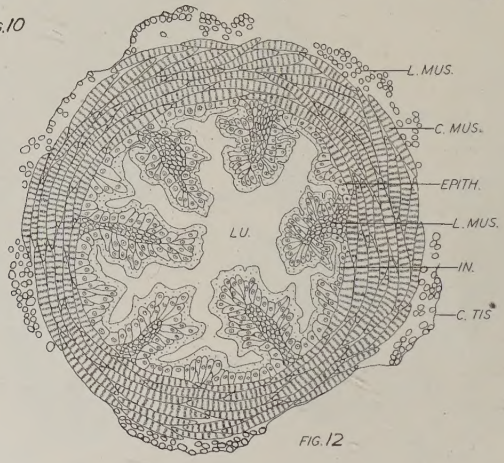


FIG. 12